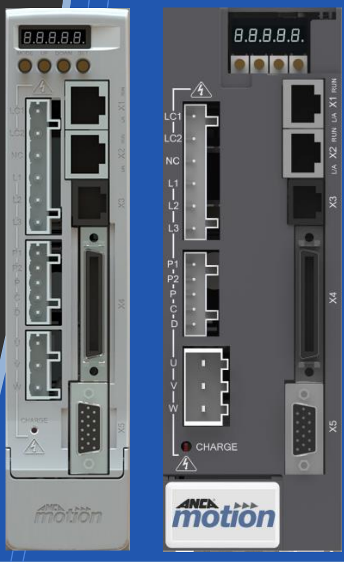
AMD2000 Series - Servo Drive User Manual



DS619-0-00-0019 – Rev 0

AMD2000 Series - Servo Drive
User Manual

Related Manuals and brochures	*Related Documents*
Sales and Support Contact Information	*Product, Sales and Service Enquiries*
For the latest copy of the manual visit us online	*Manuals*
For the latest version of the ANCA MotionBench Software visit	*Software*

Documents reference: DS619-0-00-0019 - Rev 0

Effective: 8-04-2013

Chapter Summaries

1	Safety	General Product safety information
2	Introduction	Target Audience, model applicability, help in reading the manual and related manuals/brochures
3	Product Overview	Features, operating principles, labels, connector overview
4	Mechanical Installation	Requirements for site, tools, mounting, and cooling
5	Planning the Electrical Installation	Motor and drive compatibility, electrical isolation, protection, cable selection and routing
6	Power Wiring	Insulation, earthing, power conditioning, brake connection and regenerative brake
7	Control Wiring	Electrical Interfacing with the I/O connectors, EtherCAT and motor feedback
8	Installation Checklist	Pre-power-up checks
9	Start-up	Installing and using ANCA Motion Bench to configure and enable the drive
10	Feature Configuration	Feature description and configuration information
11	Fault Tracing	Indicators, drive states and diagnostics
12	Technical Data	Functions, specifications, dimensions, de-rating, brake resistor calculation, standards compliance
13	Accessories	Selection of accessories including motors, cables, I/O interface modules, filters, reactors, chokes magnetic cores
13	Accessories What this Chapter Contains	

Contents

1. Safety

Warning: To prevent possible accidents or injury, ensure you read and understand this manual before commencing installation or service work on the AMD2000 drives.

DANGER HIGH VOLTAGE - The working DC bus is live at all times when power is on. The Main Isolator feeding the drive must be switched to the **Off** position at least 15 minutes before any work is commenced on the unit. The operator must check the bus voltage with a tested working voltage measuring instrument prior to disconnecting any connectors or opening the DC Bus terminal cover. The red LED indicator on the front of the drive which indicates that there is charge remaining in the drive is only to be used as an aid to visual troubleshooting. It shall **not be relied on as a means of safety.**

This manual and the warnings attached to the AMD2000 only highlight hazards that can be predicted by ANCA Motion. Be aware they do not cover all possible hazards.

ANCA Motion shall not be responsible for any accidents caused by the misuse or abuse of the device by the operator.

Safe operation of these devices is your own responsibility. By taking note of the safety precautions, tips and warnings in this manual you can help to ensure your own safety and the safety of those around you.

The AMD2000 is equipped with safety features to protect the operator and equipment. Never operate the equipment if you are in doubt about how these safety features work.

1.1 General Safety

The following points must be understood and adhered to at all times:

- Equipment operators must read the user manual carefully and make sure of the correct procedure before operating the AMD2000.
- Memorize the locations of the power and drive isolator switches so that you can activate them immediately at any time if required.
- If two or more persons are working together, establish signals so that they can communicate to confirm safety before proceeding to another step.
- Always make sure there are no obstacles or people near the devices during installation and or operation. Be aware of your environment and what is around you.
- Take precautions to ensure that your clothing, hair or personal effects (such as jewelry) cannot become entangled in the equipment.
- Do not remove the covers to access the inside of the AMD2000 unless authorized
- Do not turn on any of the equipment without all safety features in place and known to be functioning correctly. Never remove any covers or guards unless instructed by the procedures described in this manual.
- Never touch any exposed wiring, connections or fittings while the equipment is in operation.
- Visually check all switches on the operator panel before operating them.
- Do not apply any mechanical force to the AMD2000, which may cause malfunction or failure.
- Before removing equipment covers, be sure to turn OFF the power supply at the isolator. (Refer to *4.4.11 Power Isolation*.) Never remove the equipment covers during operation.
- Keep the vicinity of the AMD2000 clean and tidy.

- Never attempt cleaning or inspection during machine operation.
- Only suitably qualified personnel should install, operate, repair and/or replace this equipment.
- Be aware of the closest First Aid station.
- Ensure all external wiring is clearly labelled. This will assist you and your colleagues in identifying possible electrical safety hazards.
- Clean or inspect the equipment only after isolating all power sources.
- Use cables with the minimum cross sectional area as recommended or greater.
- Install cables according to local legislation and regulations as applicable.
- Insulation resistance testers (sometimes known as a ‘megger’ or hi-pot tester) are not to be used on the drive, as a false resistance reading and/or damage to the tester may result
- If an inductor (choke) is placed between terminals P1 and P2 the choke shall be designed to drop less than 5% of the line voltage.

1.2 Safe Start-Up and Operation

Please refer to sections *8 Installation Checklist* and section *9.6.12 Power-On Checks* for additional checks that should be made to start up the AMD2000 series drives safely.

2. Introduction

2.1.11 What this Chapter Contains

This chapter introduces reader to the manual, the target audience and some useful information with regards to comprehending the content.

2.1.12 Purpose

This manual provides the required information for planning to install, installation, commissioning, operation and servicing of the AMD2000 Series Servo Drive. It has been written specifically to meet the needs of qualified engineers, tradespersons, technicians and operators.

Every effort has been made to simplify the procedures and processes applicable to the AMD2000 in this user manual. However, given the sometimes complex nature of the information, some prior knowledge of associated units, their configuration and or programming has to be assumed.

2.1.13 About the AMD2000 drive

The AMD2000 Series Servo Drives are capable of motion control for applications that may vary from precise control of movement and angular position of permanent magnet synchronous motors through to less rigorous applications such as simple speed control of induction motors. In many of these applications the rotational control of the motor is converted to motion using mechanical means such as ball screws and belts.

Motion control is performed by the drive controller which accepts position feedback from motor encoders and/or separate linear scales. The drive utilizes state-of-the-art current-regulated, pulse-width-modulated voltage-source inverter technology that manages motor performance. In general, the Drive control receives motion control commands via a higher level controller, which is based on an Ethernet-based field-bus interface. In certain applications the drive is capable of executing pre-defined moves that are stored in local memory, without the use of a motion controller. The AMD2000 drive also supports position, velocity and torque control modes.

Please refer *to 3.2 Features* for more details of features available

2.1.14 Drive Model Applicability

This manual is applicable to the following variants of the ANCA Motion AMD2000 Series Servo Drives:

Product	Product variant	Product Number
AMD2000 Series Servo Drive	3A rms	D2003-2S1-A
	9A rms	D2009-2S1-A

2.1.15 Related Documents

AMD2000 Series AC Servo Drive Brochure - DS619-0-01-0008

Alpha Series AC Servo Motor Brochure - DS619-0-01-0007

Digital Servo Drive SoE Parameter Reference – Included with the firmware bundle

Digital Servo Drive Error Code Reference - Included with the firmware bundle

2.1.16 Terms and Abbreviations

DSD	Digital Servo Drive
EMC	Electromagnetic Compatibility
IEC	International Electrontechnical Commission
I/O	Bidirectional Input / Output
O	Output
AIN	Analog Input
AOUT	Analog Output
DI	Digital Input
DO	Digital Output
W.R.T.	With Respect To
GND	Ground
rms	root mean square
V / mV	Volt / millivolt
A / mA	Ampere / milliampere
Φ / Ø	phase
Ω	ohms
AC / DC	Alternating Current / Direct Current
Hz	Hertz
ms	millisecond
SoE	Servo Profile Over EtherCAT
CNC	Computer Numerical Control
DCH	Drive-Controlled Homing
DCM	Drive-Controlled Moves
PMSM	Permanent Magnet Servo Motor
PMAC	Permanent Magnet Alternating Current

2.1.17 Trademarks

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

3. Product Overview

3.1 What this Chapter Contains

This chapter introduces reader to the AMD2000 3A and 9A servo drive by providing the following information

- Features,
- Operating Principle
- Explanation of Labelling and Markings
- Connector overview

3.2 Features

The AMD2000 is a versatile brushless AC servo drive incorporating a digital signal processor (DSP) for control of rotary and linear motors. In general, the drive receives motion commands via a higher level controller, such as a CNC, either in the form of structured position commands, or as a series of instructions controlling one or more user pre-defined moves stored locally on the drive. The communication is based on the state-of-the-art EtherCAT® interface. In certain applications the drive is also capable of running in standalone mode executing pre-defined repetitive moves

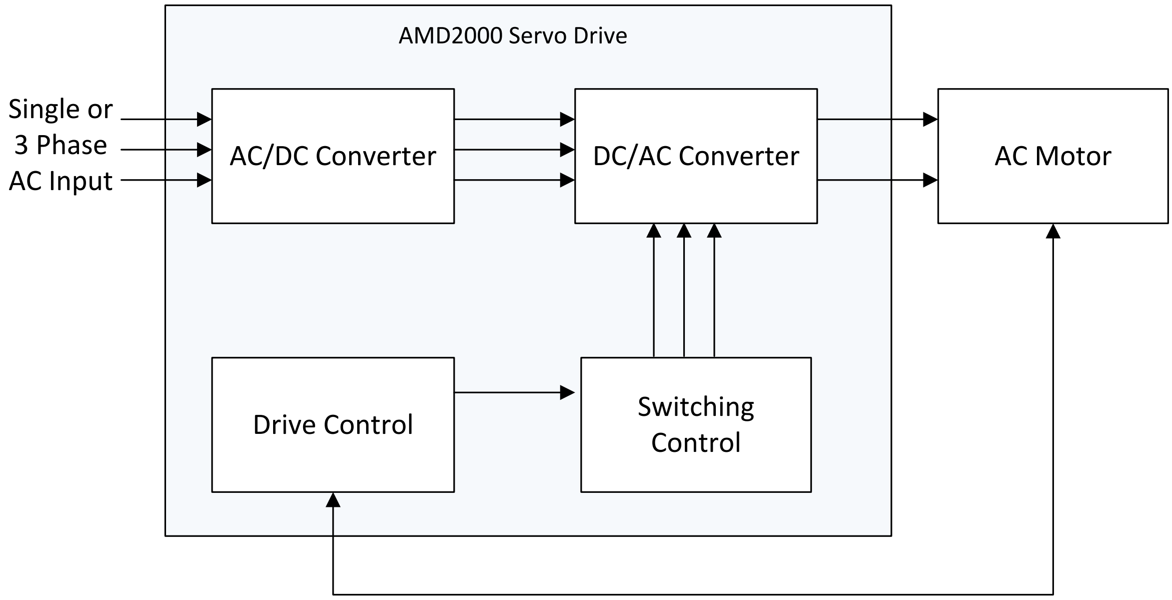
Standard features include:

- Single axis drive for AC synchronous servo motors and induction motors.
- Models with continuous current ratings of 3A or 9A.
- Direct connection to 105V – 265VAC single phase or 3-phase.
- Support for incremental analog and digital encoders, as well as absolute encoders.
- Position, velocity and torque/current control.
- Modbus communication port (RS422/RS485/RS232)
- Display and push buttons for standalone operation.
- 8 optically isolated general purpose digital inputs.
- 6 optically isolated general purpose digital outputs.
- 2 differential digital inputs (optionally can be used as additional general purpose digital inputs, for a total of 10)
- 2 analog inputs (±10V) and 1 analog output (±10V).
- EtherCAT® connectivity.
- Easy setup using ANCA MotionBench Tool.
- Small foot print. On-board 24VDC power supply and auxiliary I/O reduce overall system size and cost.
- Rugged and reliable design

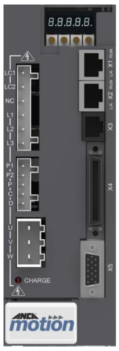
Please refer to section *12.Technical Data* for detailed product specifications

3.3 Operating Principle

The simplified circuit diagram of the drive is shown below. The AC supply voltage is converted to DC, which is then converted into the required AC voltage signal to drive the motor.

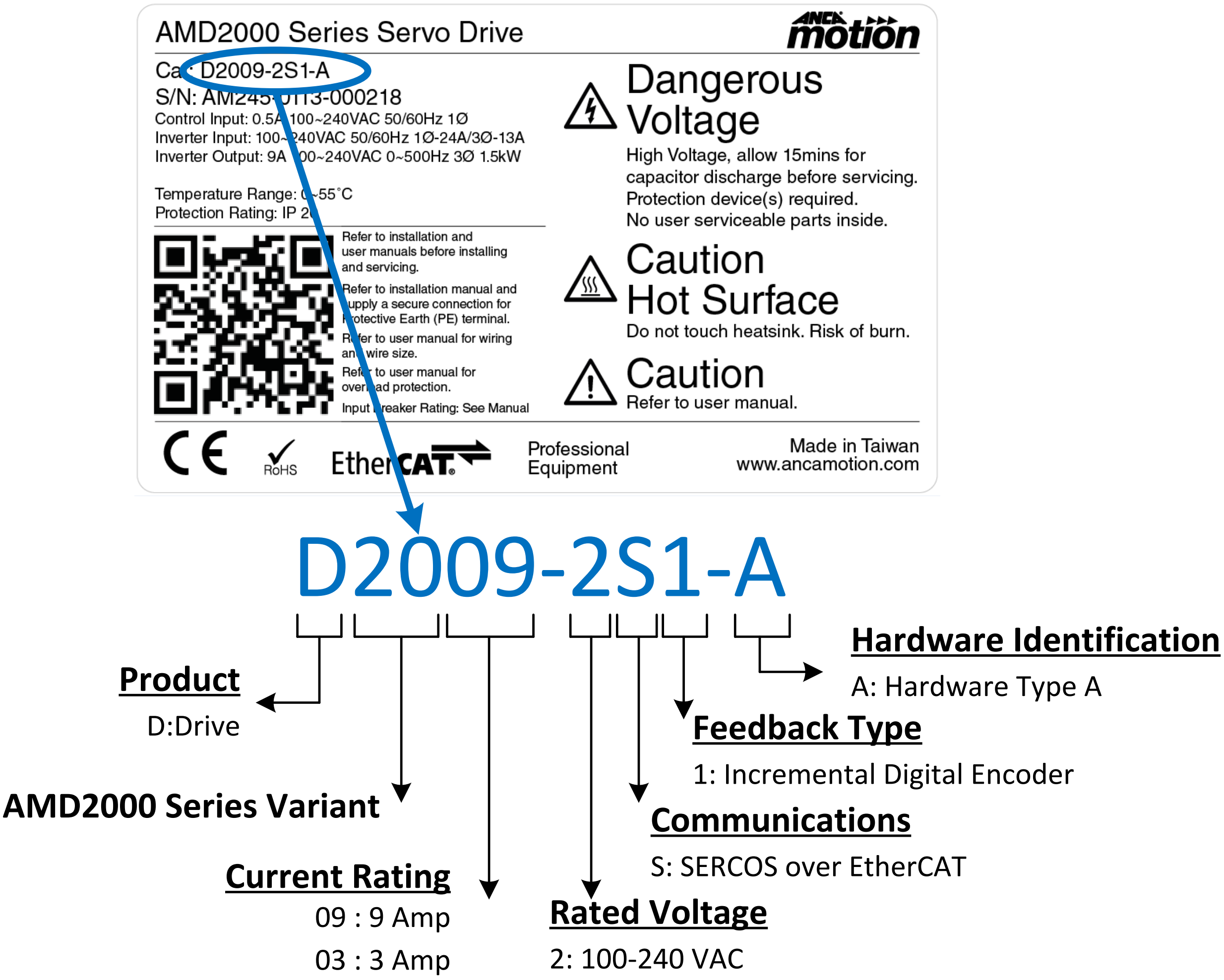


3.4 AMD2000 Variant Identification

AMD2000 3A		AMD2000 9A	
			

3.4.11 AMD2000 Series Drive Catalogue Number Interpretation

AMD2000 drives are marked with an identification label. The Catalogue number is explained as follows:



For any warranty work to be undertaken these labels must be readable and undamaged. Care should be taken to record these numbers in a separate register in the event of damage or loss.

Note: Do not under any circumstances tamper with these labels. Your warranty may be void if the labels are damaged.

3.5 System Overview

A digital drive system comprises one or more digital servo drives as shown in the following Figure:

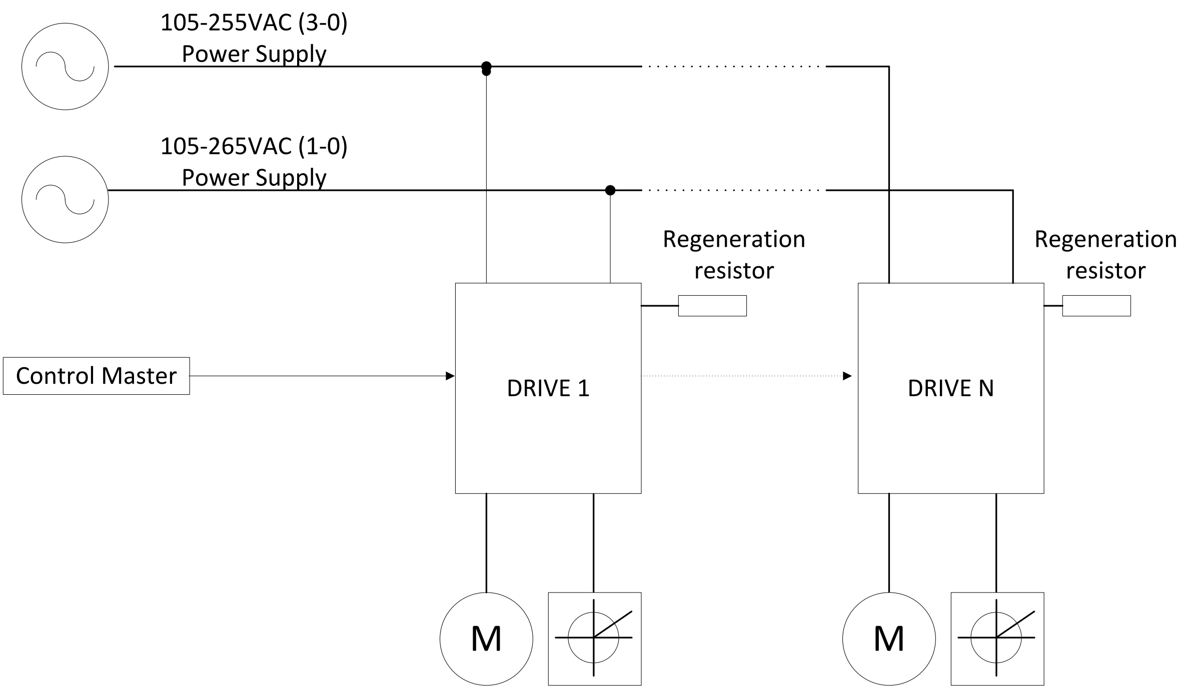


Figure 3-1 1.1 System Overview

Above example is of a drive system is supplied from a single phase mains connection with a nominal voltage of 230VAC. Motion control commands are received from a control system, such as a CNC, either in the form of structured position commands, or as a series of instructions controlling one or more user pre-defined moves stored locally on the drive.

If required, the control of an external mains contactor is provided by a user defined output from the Drive.

The following figure provides a block diagram of the drive system. There are two versions of drive system available corresponding to maximum continuous motor current ratings of 3A and 9A. The communications channel is routed between the components within the drive system and the external control system via CAT5E or CAT6 Ethernet cabling. This communications channel provides interconnectivity for the purpose of transmitting and receiving data, such as position commands. A number of analog inputs and digital inputs/outputs are provided in each drive for user defined signals which may be used for application specific functions.

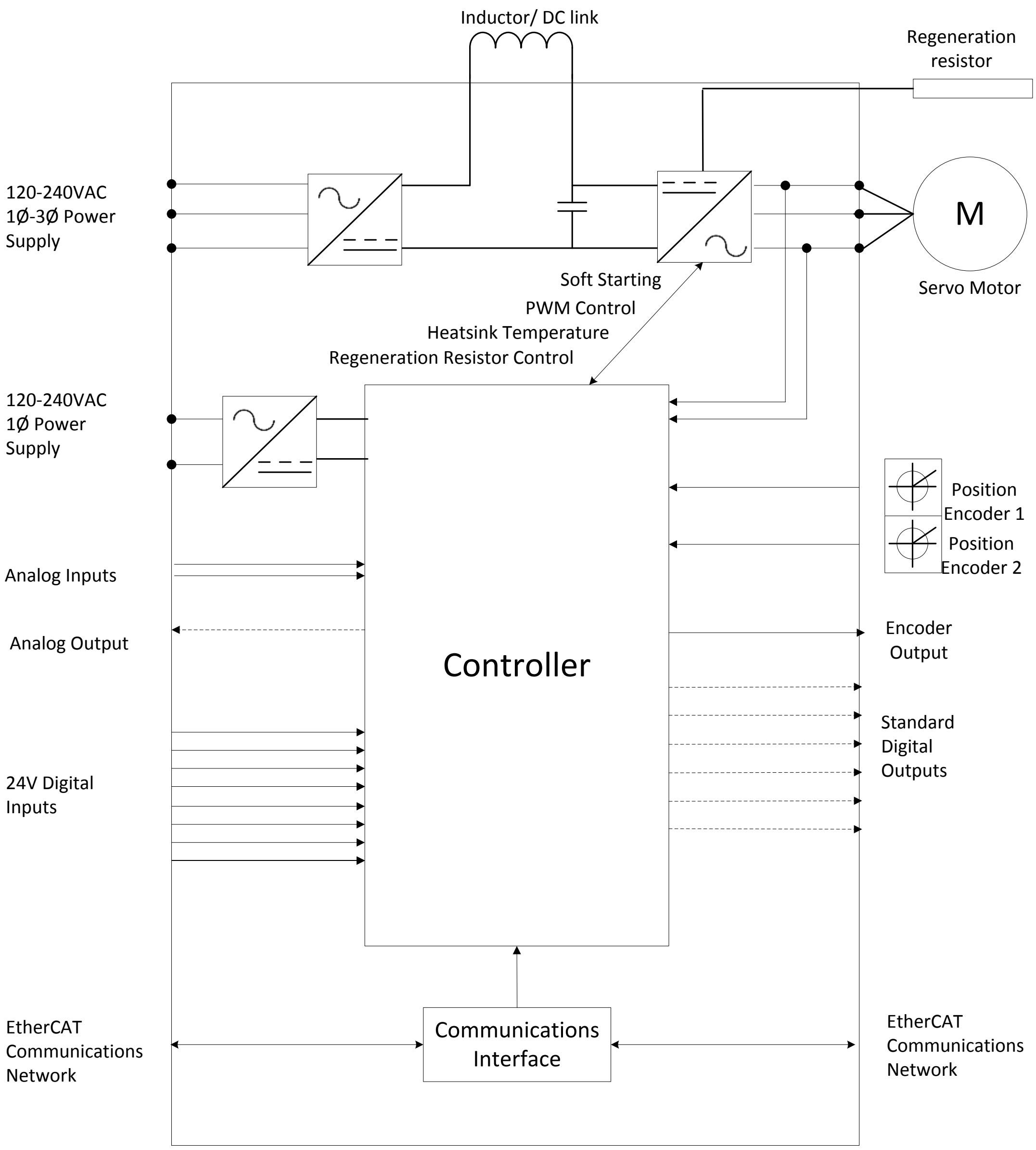
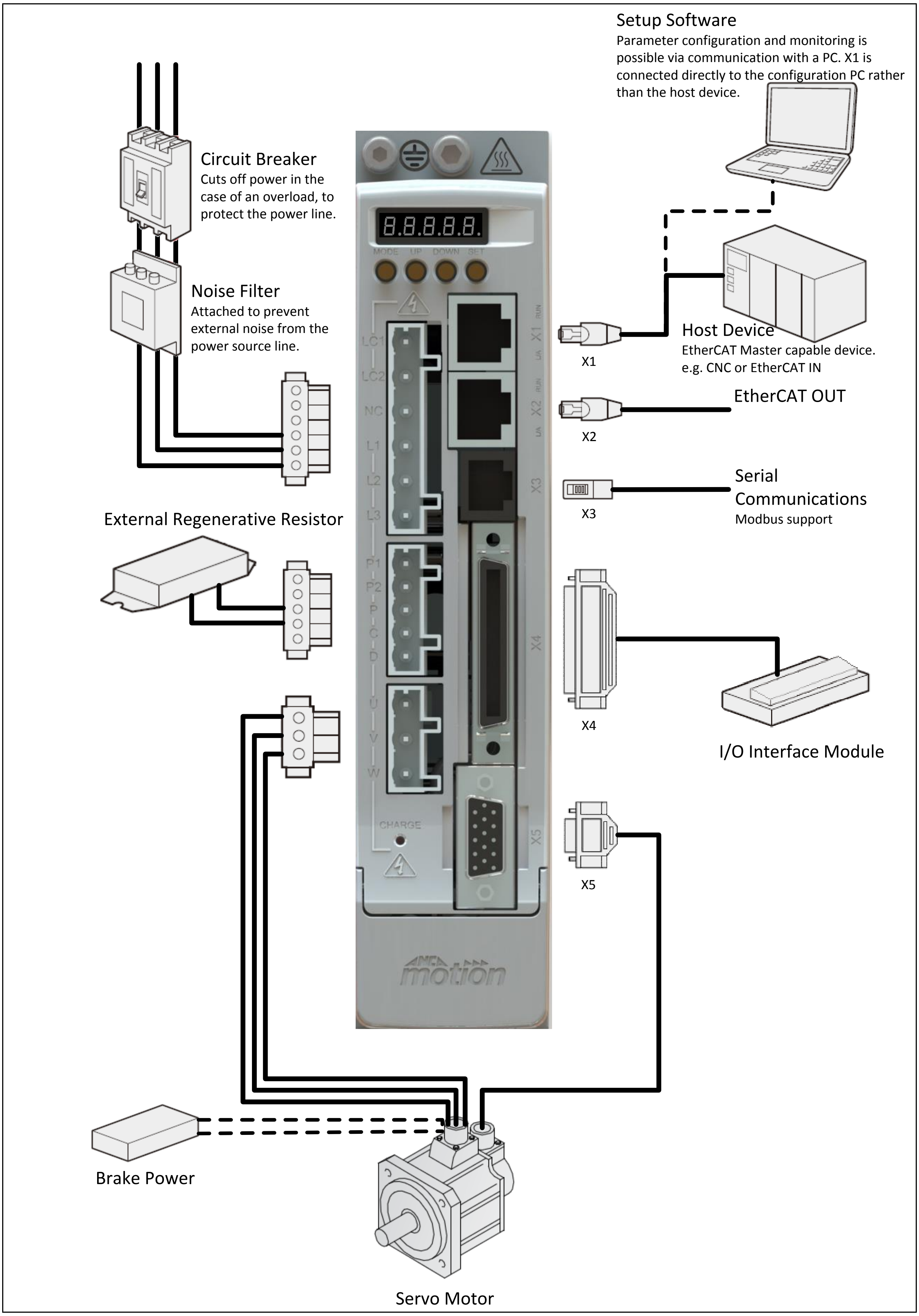
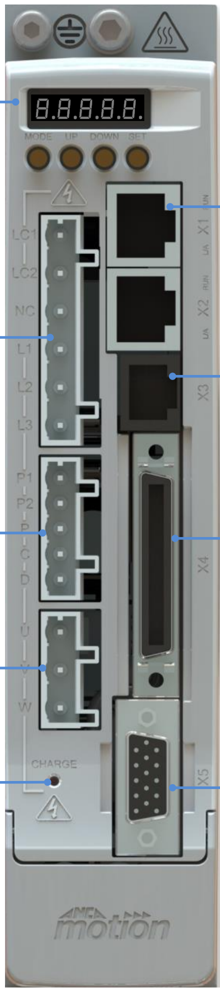


Figure 3-2 Block Diagram of the Drive System


Setup Software
Parameter configuration and monitoring is possible via communication with a PC. X1 is connected directly to the configuration PC rather than the host device.
Circuit Breaker
Cuts off power in the case of an overload, to protect the power line.
Noise Filter
Attached to prevent external noise from the power source line.
External Regenerative Resistor
Host Device
EtherCAT Master capable device.
e.g. CNC or EtherCAT IN
X1
EtherCAT OUT
X2
Serial Communications
Modbus support
X3
X4
I/O Interface Module
X5
Brake Power
Servo Motor

3.6 Connector Overview

3.6.11 AMD2000 3A



7 Segment Display

X1/X2 EtherCAT IN/OUT

Ethernet Interface Protocol:	EtherCAT
Baud Rate:	100 MB/s
Drive Profile Definition:	SERCOS
Connection:	Ethernet RJ-45

AC Supply

PIN	SIGNAL
LC1	Control Voltage Single Phase Supply
LC2	Control Voltage Single Phase Supply
NC	Not Connected
L1	Single/Three Phase Supply
L2	Single/Three Phase Supply
L3	Single/Three Phase Supply

X3 Serial Communications

X4 Input/Output

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
1	AI-01 +	18	DI-10-	35	EO-A+
2	AI-02 +	19	DO-01	36	EO-A-
3	AGND	20	+24V	37	EO-B-
4	AGND	21	+24V	38	EO-B+
5	NC	22	DO-02	39	EO-Z-
6	NC	23	DO-03	40	EO-Z+
7	DI-01	24	DO-04	41	NC
8	DI-02	25	DO-05	42	NC
9	DI-03	26	AI-01-	43	NC
10	DI-04	27	AI-02-	44	NC
11	DI-05	28	AO-01	45	NC
12	DI-06	29	Do Not Connect	46	GND (24V)
13	DI-07	30	AGND	47	GND (24V)
14	DI-08	31	AGND	48	NC
15	DI-09+	32	NC	49	NC
16	DI-09-	33	NC	50	NC
17	DI-10+	34	DO-06		

DC Link and External Regen

PIN	SIGNAL
P1	External Inductor Connection
P2	External Inductor Connection
P	Braking Resistor
C	Braking Resistor
D	Braking Resistor

Armature/Motor Connection

PIN	SIGNAL
U	Motor Connection
V	Motor Connection
W	Motor Connection

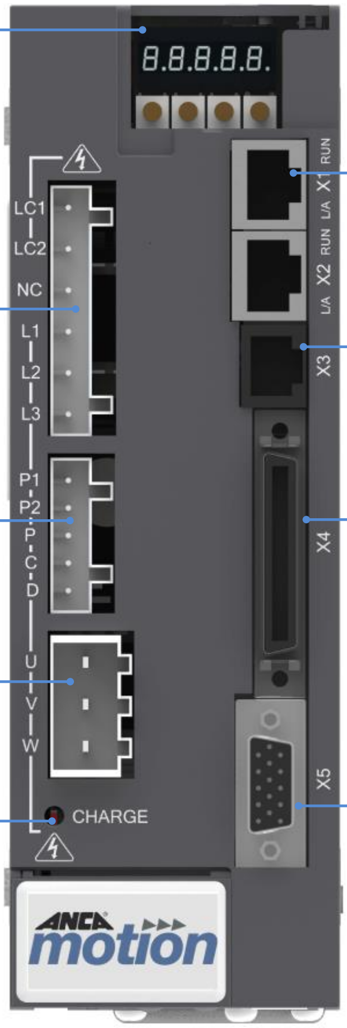
DC Bus Charge Indicator

X5 Encoder Interface

PIN	SIGNAL	PIN	SIGNAL
1	SIN- / A-	9	B+
2	SIN+ / A+	10	B-
3	COS- / B-	11	Z+
4	COS+ / B+	12	Z-
5	Data- / Ref- / Z-	13	9VDC
6	Data+ / Ref+/ Z+	14	5VDC
7	A+	15	GND
8	A-		

Figure 3-3 Connector Summary AMD2000 D2003 Servo Drive

3.6.12 AMD2000 9A



7 Segment Display

X1/X2 EtherCAT IN/OUT

Ethernet Interface Protocol:	EtherCAT
Baud Rate:	100 MB/s
Drive Profile Definition:	SERCOS
Connection:	Ethernet RJ-45

AC Supply

PIN	SIGNAL
LC1	Control Voltage Single Phase Supply
LC2	Control Voltage Single Phase Supply
NC	Not Connected
L1	Single/Three Phase Supply
L2	Single/Three Phase Supply
L3	Single/Three Phase Supply

X3 Serial Communications

DC Choke and External Regen

PIN	SIGNAL
P1	External Inductor Connection
P2	External Inductor Connection
P	Braking Resistor
C	Braking Resistor
D	Braking Resistor

X4 Input/Output

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
1	AI-01 +	18	DI-10-	35	EO-A+
2	AI-02 +	19	DO-01	36	EO-A-
3	AGND	20	+24V	37	EO-B-
4	AGND	21	+24V	38	EO-B+
5	NC	22	DO-02	39	EO-Z-
6	NC	23	DO-03	40	EO-Z+
7	DI-01	24	DO-04	41	NC
8	DI-02	25	DO-05	42	NC
9	DI-03	26	AI-01-	43	NC
10	DI-04	27	AI-02-	44	NC
11	DI-05	28	AO-01	45	NC
12	DI-06	29	Do Not Connect	46	GND (24V)
13	DI-07	30	AGND	47	GND (24V)
14	DI-08	31	AGND	48	NC
15	DI-09+	32	NC	49	NC
16	DI-09-	33	NC	50	NC
17	DI-10+	34	DO-06		

Armature/Motor Connection

PIN	SIGNAL
U	Motor Connection
V	Motor Connection
W	Motor Connection

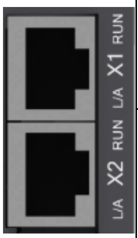
DC Bus Charge Indicator

X5 Encoder Interface

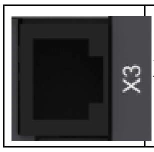
PIN	SIGNAL	PIN	SIGNAL
1	SIN- / A-	9	B+
2	SIN+ / A+	10	B-
3	COS- / B-	11	Z+
4	COS+ / B+	12	Z-
5	Data- / Ref- / Z-	13	9VDC
6	Data+ / Ref+/ Z+	14	5VDC
7	A+	15	GND
8	A-		

Figure 3-4 Connector Summary AMD2000 D2009 Servo Drive

3.6.12.1 X1/X2 EtherCAT Connectors

	X1	EtherCAT IN
	X2	EtherCAT OUT

3.6.12.2 X3 Serial Communications

	X3	The X3 serial port is an RS232 and RS485 communications interface which implements the Modbus protocol. Not enabled on this model

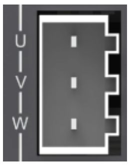
3.6.12.3 X4 Input / Output

	X4	Connection interface to analogue and digital inputs and outputs

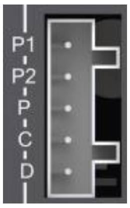
3.6.12.4 X5 Encoder Interface

	X5	Port for an encoder interface. Its purpose is to provide encoder position feedback to axis 1.

3.6.12.5 Motor Armature Cable Connectors

	U V W	Motor armature cable connection

3.6.12.6 Inductor, Brake Resistor Connectors

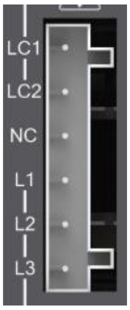
	P1 P2	External inductor connection. P1 and P2 are in series with DC BUS+ and might be connected to an external inductor for extra energy storage and reducing voltage ripple.
	P,C,D	Brake resistor connection

To be able to use the drive without an external inductor – a link rated at full drive current must be placed across P1 and P2 to avoid E0303 DC bus Voltage low alarm.

If an external brake resistor is not installed a link must be placed across P and D to be able to take advantage of the internal brake resistor to dissipate regenerative energy.

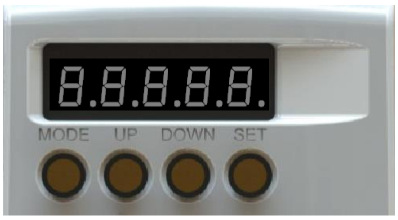
For Additional Information refer to section *6.6 Power Supply Filters & 6.13 Brake/Regeneration Resistor.*

3.6.12.7 Control Power and DC Bus Power Connectors

	LC1 LC2	Single phase supply for control power
	NC	Not Connected
	L1 L2 L3	Single phase or three phase supply for DC bus

3.6.12.8 LED Display and Control Panel

The AMD2000 series drives are fitted with a LED display and control panel as shown in the following figure:



The characteristics of the display and control panel are detailed in the following table:

Drive Display	
Indicator	5 x 7-segment LED
Operator interfacing	4 DIP buttons

The 7 segment LED display on the AMD2000 serves three functions. It is used to report errors, to indicate the state of the EtherCAT communications and to indicate the state of the drive.

The dots represent wire saving encoder UVW sensor feedback state on power up.

3.6.12.9 Error state

In an error condition, the display will read either **E-###** where **###** refers to the relevant error code. See section *11 Fault Tracing* for the description and possible causes for the error.

When no error has been reported, the display will provide information on both the drive state and the communications state.

3.6.12.10 Communications state

To indicate the state of the EtherCAT communications, the leftmost digits of the display will read **C#**, where # refers to the current communications condition as shown in the following table:

C#	Communications State
C0	None
C1	Initialization
C2	Pre-operational
C4	Safe-operational
C8	Operational

3.6.12.11 Drive state

To indicate the state of the drive, the rightmost digits of the display will read d#, where # refers to the current drive condition as shown in the following table:

d#	Drive State
d0	Off
d2	Ready to operate
d3	Enabling
d4	Enabled

4. Mechanical Installation

4.1 What this Chapter Contains

This chapter contains information that is relevant to the mechanical installation of the drives in an electrical cabinet such as

- Pre installation checks
- Installation site requirements
- Tools required
- Mounting and cooling
- EMC armature cable shield termination

4.2 Pre installation checks

- Prior to installing the drive into the electrical cabinet, check the information on the designation label (located on the side of the drive). Please refer to section *3.4 AMD2000 Variant Identification*.
- Check that drive was not damaged during transport. If there are signs of damage the drive may not be safe to use. Please notify shipper immediately of the damage and DO NOT install the drive into the electrical cabinet.

4.3 Requirements

4.3.11 Installation Site

- The AMD2000 Series Servo Drive must only be installed indoors, permanently fixed to the electrical cabinet, and fitted by trained, qualified personnel.
- Refer to the *4.3.13 Mounting and Cooling* for the correct installation process.
- The safety precautions outlined in *1Safety* must be understood and adhered to.
- The operating environment must not contain corrosive substances, metal particles, dust, flammable substances or gases.
- Ensure that there are no devices mounted adjacent to the drives that produce magnetic fields. If you need to mount these devices next to the drives, ensure that there is a safe distance between them or shield the magnetic fields.
- The maximum recommended operating altitude is 1000m above sea level
- The AMD20000 must not be installed in an environment in which the pollution degree (according to IEC 61800) exceeds 2
- Failure to follow these instructions may result in drive failure or degraded operation.

Refer to *12.6 Environmental Specifications* for further requirements

4.3.12 Tools Required

In order to mount the AMD2000 drive, the following tools are required as a minimum.

- 4mm Hex key with ball end for the M5x0.8P
- 3mm Hex Key with ball end for the M4x0.7P
- M5 x0.8P screws with spring and flat washer for AMD9A only. Screw length 30mm
- A small flat blade screw driver for X5 D-Sub 15pin HD connector, and X4 50 way Digital I/O connector.
- Connectors are to be installed using only the crimp tool specified by the connector manufacturer

4.3.13 Mounting and Cooling

- The AMD2000 must be installed vertically (see below for installation process).
- Adequate ventilation for the drive must be provided, and the drive must not be installed in the vicinity of other heat generating equipment or devices
- The 3A drive is designed to operate without any additional cooling methods.
- The 9A drive has a cooling fan inside to allow the heat sink to be cooled.
- Both the 3A and 9A drives are intended to be mounted in electrical cabinets and it is the responsibility of the installer to ensure the drives are adequately earthed through the provided protected earthing points denoted with the ⏚ symbol. Use appropriate ring terminals for this connection.
- If armature termination brackets are required to be fitted for EMC compliance see page for fitting instructions.
- The 3A drive operates without an additional cooling method, whereas the 9A drive requires forced air flow from a fan to allow full operation within the acceptable temperature range
- If the required cooling and air flow requirements are not met, performance of the AMD2000 will deteriorate and the product lifetime will be reduced
- The AMD2000 should be mounted on a panel with a minimum thickness of 3mm.

4.3.13.1 Mounting of drives for effective cooling inside the electrical cabinet:

- The AMD2000 drives should be mounted with at least 50mm clearance above and below to allow for effective cooling
- The AMD2000 3A drive must have at least 15mm horizontal space between itself and the cabinet wall, and at least 30mm space between adjacent drives
- The AMD2000 9A drive must have at least 8mm horizontal space between itself and the cabinet wall, and at least 15mm space between adjacent drives.

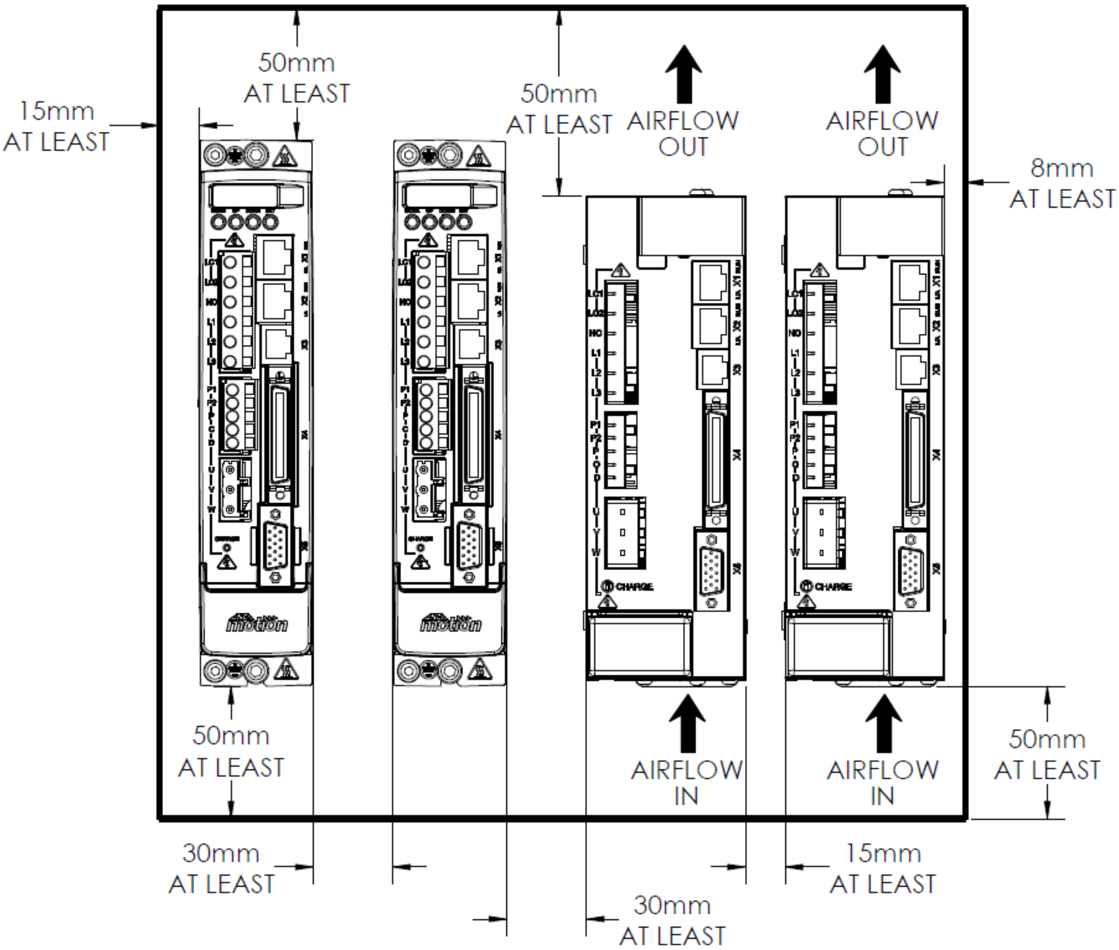


Figure 4-1 Installation in a single row

If multiple rows of drives are required to be installed, follow the layout below for this arrangement.

- If drives are to be mounted in a multiple row arrangement, please ensure that the drives are offset / staggered at least a full drive width apart to maintain effective cooling. For 3A drives at least 43mm apart, 9A drives at least 60mm apart).
- Ensure there is a minimum gap between each row of drives. For 3A drives at least 30mm apart, 9A drives at least 50mm apart.

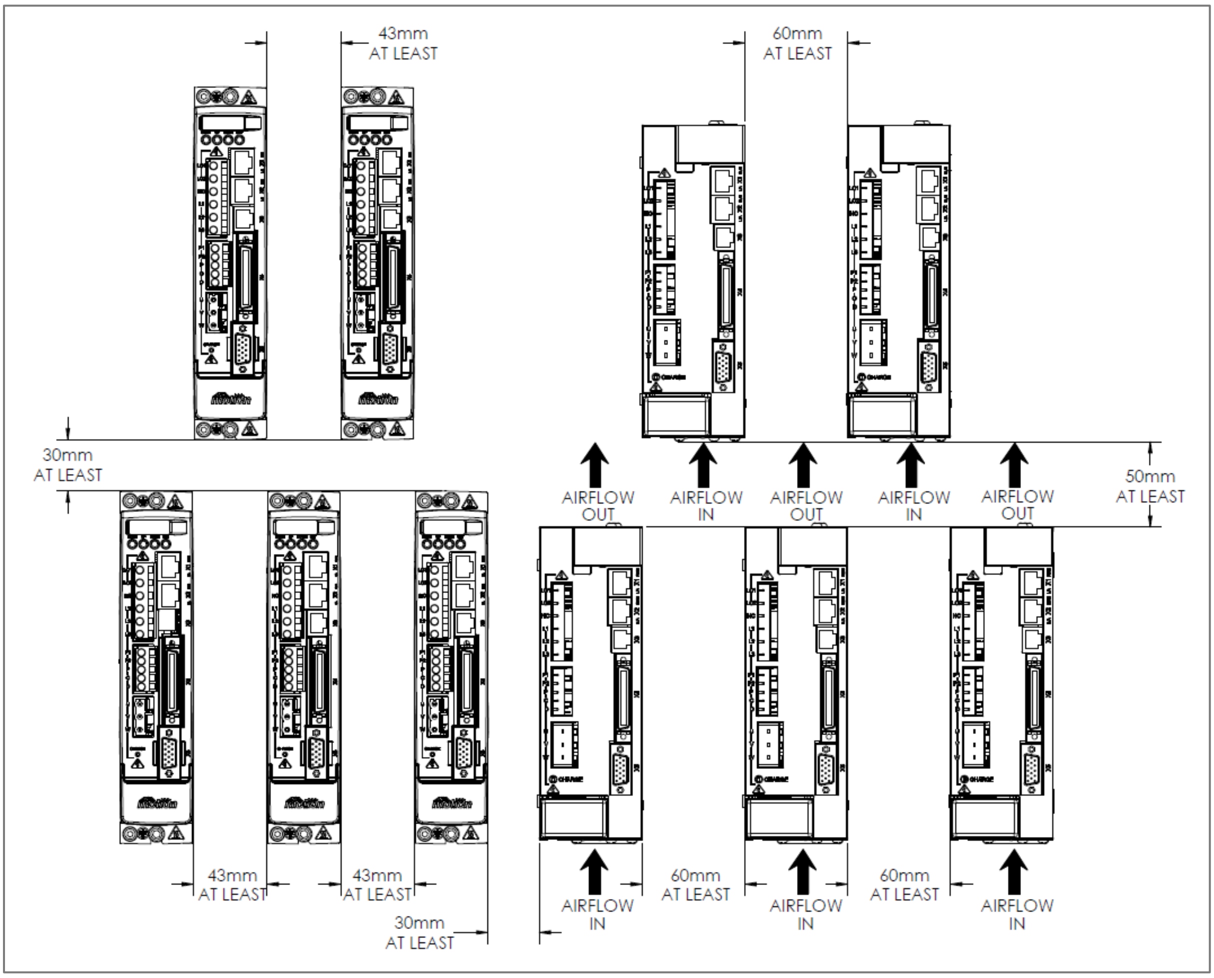


Figure 4-2 Installation in two rows

If armature termination brackets are required to be fitted for EMC compliance, Refer to *6.8.12.1.1 Installation of the EMC Clamp on Shielded Armature Cables,* for fitting instructions.

- Refer to *12.6 Environmental Specifications* for further requirements.

4.4 Installation

4.4.11 Power Isolation

DANGER HIGH VOLTAGE - The working DC bus is live at all times when power is on. The Main Isolator feeding the drive must be switched to the **Off** position at least 15 minutes before any work is commenced on the unit. The operator must check the bus voltage with a tested working voltage measuring instrument prior to disconnecting any connectors or opening the DC Bus terminal cover. The red LED indicator on the front of the drive which indicates that there is charge remaining in the drive is only to be used as an aid to visual troubleshooting. It shall not be relied on as a means of safety.

It is recommended that the drive is installed with an upstream circuit breaker that is rated appropriately depending on the model of AMD2000 drive being installed.

Turn the Main Disconnect mains isolator switch to the Off position.

Following the appropriate lockout procedure, place a sign over the isolation switch clearly indicating to other personnel that this isolator is not to be touched.

4.4.12 Mounting a Drive

Refer to section *12.7 Dimension Drawings* for drive dimensions and mounting hole positions.

STEP 1

Drill and tap 2 x M5x0.8P holes to suit hole pattern described in section *12.7 Dimension Drawings.* Overlap the drive onto the drilled holes to ensure that the hole positions are correct. Ideally the sheet metal panel should be a minimum 3mm thick.

STEP 2

Fit one of the M5 mounting screws partially into the lower drilled and tapped hole so that the majority of the screw thread is evident (A).

STEP 3

Position the drive so that the holes with the heat sink line up with the holes in the cabinet. There is an open slotted hole at the bottom of the heat sink. Insert the drive so that the screw fits within the open slotted hole (B) for location and then pivot the drive onto the cabinet (C).

STEP 4

Secure the drive to the cabinet by fitting the remaining M5 mount screw into the upper mounting hole to complete the mounting to the electrical cabinet. Tighten both M5 mounting screws (D & E) to 4~5Nm.

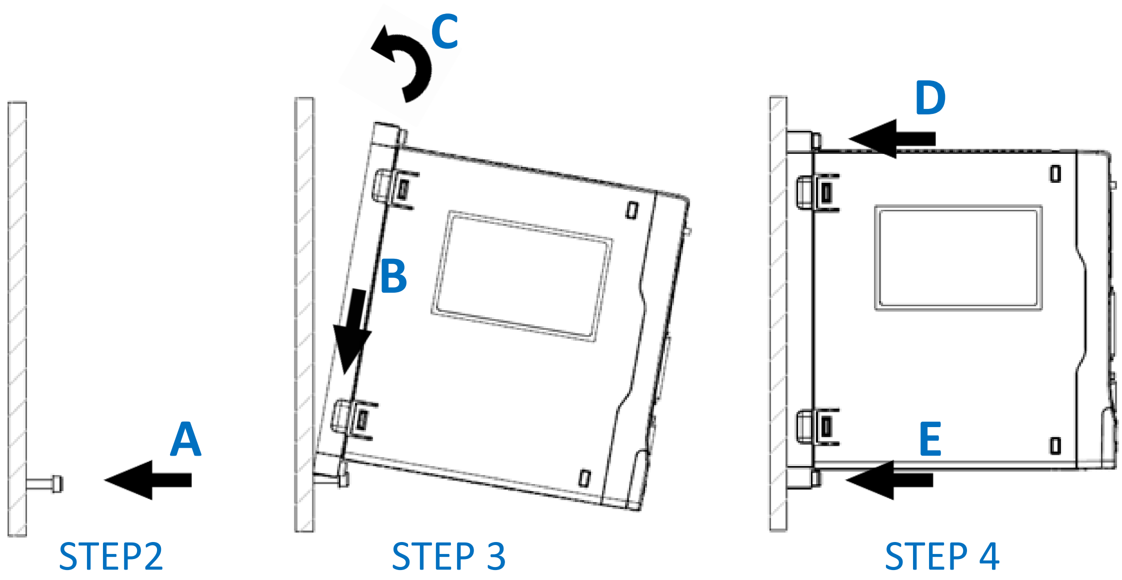


Figure 4-3 Mechanical Mounting of AMD2000 D2003 Servo Drive

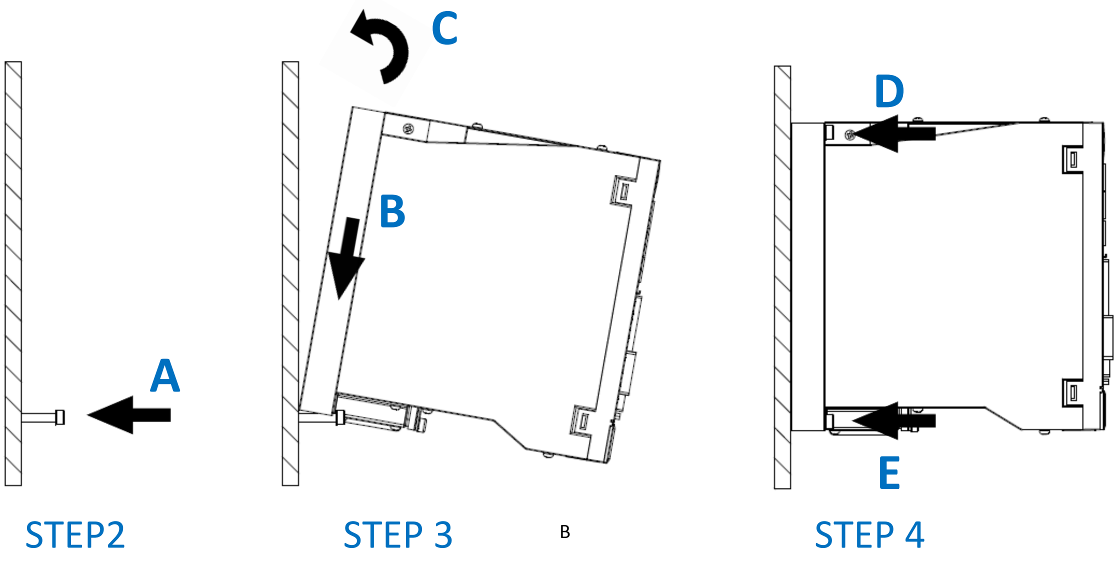


Figure 4-4 Mechanical Mounting of AMD2000 D2009 Servo Drive

STEP5

Connect appropriate electrical cables to complete installation as per sections *5 Planning the Electrical Installation* and *6 Power Wiring.*

4.4.13 Un-Mounting a Drive

Ensure mains power has been *isolated from the drives.* (see *4.4.11 Power Isolation* above)

STEP 1

Unplug the cables from the front of the drive to be un-mounted by carefully working the plugs from their sockets.

STEP 2

Follow steps 4 through to 2 of section *4.4.12 Mounting a Drive* in reverse order.

5. Planning the Electrical Installation

5.1 What this Chapter Contains

This chapter contains information that is useful in planning the electrical installation of the servo drives:

- Motor & Drive Compatibility
- Electrical Isolation and Protection Devices
- Cable Selection and Routing

The AMD200 series of drives must be installed by a professional. A professional in this context is a person or organisation possessing the necessary skills and qualifications relating to the installation and/or commissioning of power drive systems, including their EMC aspects.

5.2 Motor and Drive Compatibility

Ensure that the AMD2000 drive and the AC motor intended for use are compatible according to their respective allowable limits of operation.

Refer to *12.4.12 Digital servo drive* and *13.2.12 Motor Electrical Information Summary*

5.3 Power Supply Disconnecting Device

A mains disconnecting device must be connected between the AC power source and the AMD2000 drive. This must conform to the requirements and applicable safety regulations of the region of operation.

5.4 Emergency Stop Devices

An emergency stop device must be installed for safety reasons within easy reach of operators and maintenance personnel at all operator control stations and wherever deemed necessary.

5.5 Thermal Overload and Protection

5.5.11.1 Thermal Overload

The AMD 2000 has a built in temperature sensor that will shut off the drive when the heat sink temperature reaches a temperature that would be unsafe for continuous operation of the power switching semiconductors in the drive. The software will report a Class 1 Diagnostics error if this occurs. If this occurs please review the mechanical spacing advice and thermal de-rating curves provided by ANCA Motion and check the ambient temperature of air going to the bottom of the heat-sink in your specific application under steady state conditions.

5.5.11.2 Motor Cable Short-circuit

The AMD2000 contains features designed to protect both the motor and motor cable in the event of a short-circuit, provided the motor cable is of the required dimensions with respect to the current of the drive. This feature will trip if the current exceeds:

- 14.3A for the 3A drive
- 72.7A for the 9A drive

5.5.11.3 Supply Cable or Drive Short-circuit

The power supply cable is required to be protected via fuses or circuit breakers according to

local requirements based on cable size. Please refer to the relevant standards or legislation for the region of operation.

5.5.11.4 Motor Thermal Protection

The AMD2000 does not contain its own protection for motor thermal overload. If protection against motor thermal overload is necessary, the user must supply a thermal fuse according to the maximum safe operating temperature of the motor being protected. Please refer to *6.11 Motor Thermal Switch* for various ways Motor Protection can be incorporate in the application.

5.5.11.5 Brake Resistor

The AMD 2000 drive does not have an internal protection mechanism for the internal regeneration resistor, therefore calculating if the internal regeneration resistor is sufficient and if an additional regeneration resistor is required is paramount. Failure to do this and provide evidence of these calculations may result in burning out the resistor and voiding the warranty of your drive.

Please refer to sections *12.5.14 Regenerative Braking* and *12.14 Brake/Regeneration Resistor* for additional information.

5.6 Power Cable Selection

The power and motor cables must be selected according to regional regulations as well as usage and EMC requirements. Symmetrical shielded motor cables should be used.
The power supply cables must be rated for at least 300V AC.
The cables must be rated to withstand the expected temperature rise due to the current passing through them, given the conductor diameter, conductor material and installation environment. Such a decision is governed by local installation regulations.

To comply with EMC regulations, the cable length of the motor armature cable must not exceed 30m. The cable must be shielded and the shield must be connected to earth at both ends with appropriate terminations. At the drive end, the armature shield must be connected directly to the drive earth point. It is highly recommended that an ANCA Motion shielding bracket be used. Cable sizes should follow the wire size recommendations below.

The supply cables must be capable of handling at least the following currents:

Drive	Input supply	Cable current capability, A
AMD2000 3A	1Φ	8
	3Φ	5
AMD2000 9A	1Φ	24
	3Φ	13

The minimum required wire gauge per phase (based on 75°C Copper wire) is shown below:

Drive	Input supply	Minimum *Φ* wire gauge, mm^2
AMD2000 3A	1Φ	2.0
	3Φ	2.0
AMD2000 9A	1Φ	2.5
	3Φ	2.0

Refer to *12.4 Electrical Specifications, 13.3 Cables* for further information.

5.7 Control Cable Selection

It is strongly recommended that double shielded twisted pair cables (one individual shielded pair per signal) be used for both analogue and digital control signals (but single shielded twisted multi pair cable may be used for low voltage digital signals if desired). Analogue and digital signals must be run in separate cables. A common return path should not be used for different analogue signals. For encoder cabling, the directions given by the encoder manufacturer should be followed. Low and high voltage signals should never be run in the same cable.

Table 5-1 Motor Feedback Cable Recommendation

Signal type	Recommendation	Comment
Outer shield	Shielded length of cable	Required in ALL cases to be present and 360 degrees clamped to back shell at both ends of cable
Differential analog	Twisted Pair > 0.14mm^2 Shielded length of cable	Zo = 120 (100 also acceptable but not preferred)
		Shield terminated to 0V of X5 at AMD2000 Series Servo Drive end ONLY. If not possible terminate to back shell of X5 at AMD2000 Series Servo Drive end ONLY.
Differential digital	Twisted Pair > 0.14mm^2	Zo = 120 (100 also acceptable but not preferred)
Power	> 0.5mm^2	Shielding optional but recommended when using analogue signals. Terminate at same point as analogue shield(s) if possible, otherwise terminate to back shell at both ends
Length	<= 10m	

5.7.11 EtherCAT Wiring Details

Signal type	Recommendation	Comment
Cable	Cat 5e or above	Screened, un-shielded twisted pair (F/UTP or SF/UTP), with 8P8C modular connectors. 100m maximum.

5.8 Cable Routing

There are three main categories of cabling for the drive discussed in previous sections (above);

- Motor cables: connecting motor and drive, these supply power to/from the motors.
- Control cables: returning information from the motors to the drives (e.g. Encoder info or temp info) or running information between drives or to other control units on the machine (e.g. Relays to/from master controllers).
- Input power cables: connecting power supply unit and drive, this supplies power to/from the drives.

Care should be taken to avoid electromagnetic interference and coupling between cables.
It is recommended that all three categories of cabling be routed separately. Power and motor cables should be separated (as much as practicable) by at least 300 mm, whereas motor and control cables should maintain at least 500 mm separation over the majority of their length. If control and power cables must cross, they should cross perpendicular (at 90 degrees) to one another.

Where possible it is recommended that 24 V and 230 V cables be routed in separate ducts, and where this is not possible the 24 V cable should be appropriately insulated for 230 V.

Caution: Brake resistors can become hot. Locate them away from vulnerable components and wiring, and consider risks to personnel who maintain, install or commission the drive.

6. Power Wiring

6.1 What this Chapter Contains

This chapter contains information related to connecting the drive electrically to the incoming mains, motor and brake as well as what to be mindful of such as:

- Checking Assembly Insulation
- Cable Connection and Earthing
- Power Conditioning
- Regenerative Brake Selection / Calculation

6.2 Checking the Insulation of the Assembly

Installed supply and motor cables must be tested for functioning insulation according to local regulations by using an insulation resistance tester at 500V.

The AMD2000 drive has input supply voltage surge suppression components fitted to protect the drive from line voltage transients typically originating from lightning strikes or switching of high power equipment on the same supply. When carrying out a HiPot (Flash or megger) test on an installation in which the drive is built, the voltage surge suppression components may cause the test to fail. To accommodate this type of system HiPot test, the cables must be disconnected from the drive.

The cables to be disconnected and tested are: control voltage single phase supply (L1C/L2C), single-phase or three-phase supply (L1/L2/L3), inductor connector (P1/P2), brake resistor connector (P/C/D) and motor connector (U/V/W).

6.3 Mains Power Supply

The following components are required for connection to the mains supply:

- Isolation switch to allow correct isolation of the system from the power supply
- Fuse or circuit breakers to protect cables, filter and drive
- Line filter (optional) to limit EMI on the mains supply

The mains control supply (LC1, LC2) for the drive requires a single phase supply which can be either two phases from a 3 phase supply(120-220V line to line), or from a dedicated single phase supply (120-240V line to neutral).

The mains power supply (L1, L2, L3) can be either from two or three phases of a three phase supply(120-220V line to line), or a single phase supply (120-240V line to neutral)

The mains control supply can be linked the mains power supply allowing power to be applied at the same time. External soft start circuitry is not required. The mains and control supply cables are terminated on the 6-way connector as shown in *Figure 6-1* below.

AMD2000 drives are suitable for use on supplies of installation category III and lower, according to IEC60664-1. This means they may be connected permanently to the supply at its origin in a building, but for outdoor installation closer to primary distribution supply (overhead cables etc.) additional over-voltage suppression (transient voltage surge suppression) must be provided to reduce category IV to category III.

AC Supply

PIN	SIGNAL
LC1	Control Voltage Single Phase Supply
LC2	Control Voltage Single Phase Supply
NC	Not Connected
L1	Single/Three Phase Supply
L2	Single/Three Phase Supply
L3	Single/Three Phase Supply

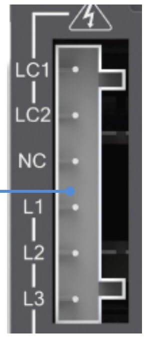


Figure 6-1 Mains Control and Power Supply Connector

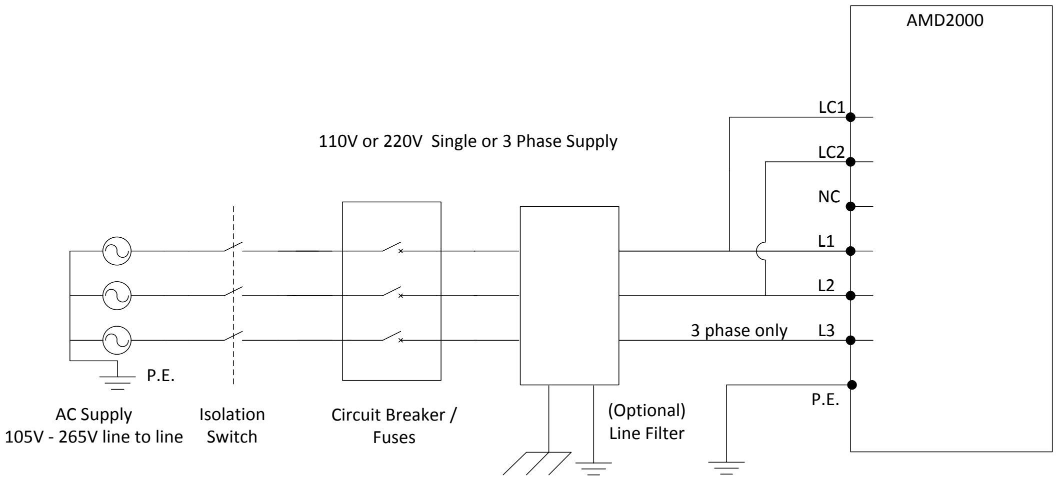


Figure 6-2 Mains Supply System for Single Phase or 3 Phase Supply

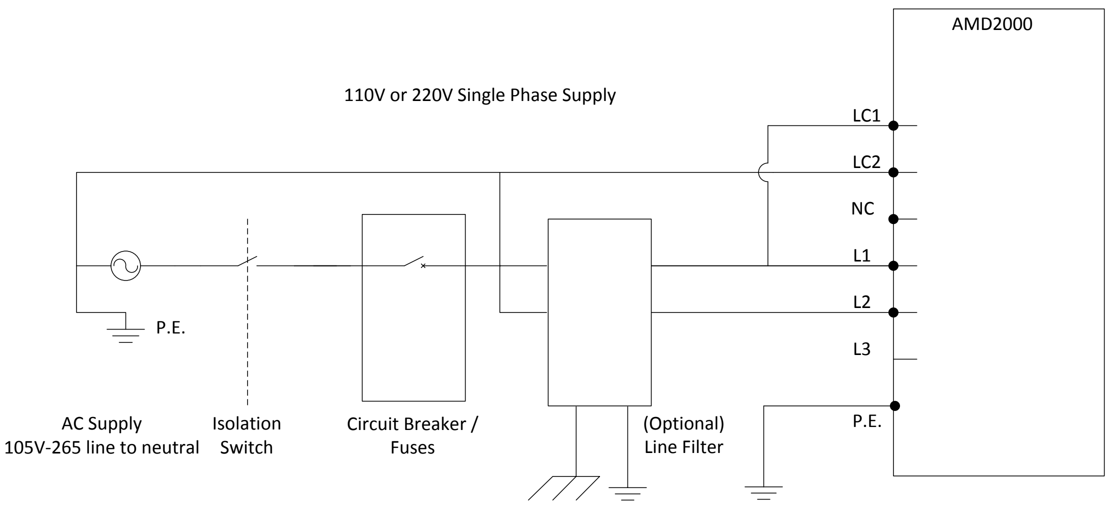


Figure 6-3 Mains Supply System for Single Phase Supply

6.3.11 Supply Voltage Ranges

The supply voltage range must be within the limits specified in *Section 12.4 Electrical Specifications*

Mains supply voltage an frequency limits		
Drive input single phase voltage range	$U_{L1\text{-}L2}$	90-265V AC
Drive input three phase voltage range	$U_{L1\text{-}L2\text{-}L2}$	90-265V AC
Maximum input voltage to Protective Earth	$U_{L1,L2,L3,\text{-}PE}$	265V AC
Nominal Input frequency	f_{LN}	50/60Hz

Operation at reduced supply voltage will require power de-rating as discussed in *12.9 Effect of AC Input Voltage on DC Bus Ripple*

Operation at single phase (and two phases) supplies instead of three phase supplies may also require the addition of more DC bus capacitors or power de-rating as discussed in *Section 12.9 Effect of AC Input Voltage on DC Bus Ripple.* The addition of external DC bus capacitors also reduces the drive susceptibility to tripping from voltage supply dips.

6.3.12 Connection of drives to grounded systems (TN or TT)

The AMD2000 series drive is designed to operate with grounded TN & TT systems where the three phase supply is from a transformer with a grounded star point. With TN & TT systems any drive, motor or wiring ground fault generates substantial currents which must be quickly interrupted with circuit breakers or fuses in the mains supply as specified in *6.7 Power Disconnect and Protection Devices.* Fast semiconductor type fuses are preferable as they provide protection to the diodes in the rectifiers of the drive, while circuit breakers are too slow to protect semiconductor devices.

No separate connection for a neutral is provided, but in single phase supplies the neutral can be connected as a phase input to L2/LC2. See *Figure 6-3* Mains Supply System for Single Phase Supply

6.3.13 Connection of drives to non-grounded systems (IT)

The AMD2000 series drive can also operate to non-grounded IT systems where the mains voltage to protective earth does not exceed 265V. The advantage of IT systems is that any drive or motor or wiring ground fault does not allow substantial current to flow and operation can be maintained in critical installations. The ground fault must be promptly detected and eliminated before a second ground fault occurs, and because higher operating voltages to earth will occur on motor cables and motor windings which may reduce the motor winding lifetime. Ground fault detection is achieved with additional insulation type monitors.

Optional EMC line filters cannot be used on IT systems as excessive ground currents may occur in the filter, and may damage the filter.

Surge arrestors connected between each supply and ground, located near the supply transformer are strongly recommended for IT supply systems.

6.3.14 Harmonics and reactive power compensated supplies

The drive input diode bridge is a non-linear load to the mains supply and generates low frequency harmonic effects in the frequency range up to 9 kHz. The harmonics can be reduced to acceptable levels with the addition of a DC bus inductor as discussed in *section 6.6.11 Harmonic Suppression.* The non-linear currents cause non-sinusoidal voltage drops across the internal resistance of the mains supply transformer and therefore distort the voltage at the point of common coupling (PCC). This may affect other equipment connected at the PCC, especially if multiple drives are connected from same supply. Calculation of the harmonics and voltage distortion is site specific.

In multiple drive installations the harmonic currents may affect power supplies equipped with reactive power compensation capacitors as resonances excited by the harmonics will occur at relatively low frequencies. Therefore, it is strongly recommended that power compensation capacitors be fitted with reactor protection to prevent harmonic resonances.

6.3.15 Residual current-operated protective (RCD) protection

Residual current-operated protective devices (RCD) provide additional protection for detection of insulation faults where current is no longer contained in power conductors.

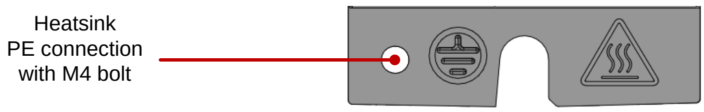
- It is only permissible to use delayed tripping, selective AC/DC-sensitive residual-current circuit-breakers, Type B.
- Parts of the electrical equipment and machine that can be touched are integrated in a protective grounding system.
- If an external EMC filter is used, a delay of at least 50ms should be incorporated to ensure spurious trips are not seen.
- The leakage current is likely to exceed the trip level if all of the phases are not energized simultaneously.
- With IT mains supply systems, RCDs are subject to nuisance tripping from drive common mode capacitors

6.4 Grounding

A grounding system has three primary functions: safety, voltage-reference, and shielding. The safety function is required by local regulations and is designated as the Protective Earth. Signal and control circuits are typically grounded at various points with the ground forming the common voltage reference. Shields on cables reduce emissions from the drive for CE compliance and protect internal circuits from interference due to external sources of electrical noise.
The Protective Earth (PE) Connection from the mains supply eliminates shock hazards by keeping parts at earth potential. The PE also conducts fault currents to earth ground until the safety device (fuse or circuit breakers) disconnects the drive from the mains.


Symbol for Protective Earth (PE)

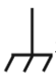
The mains supply protective (PE) cable must have a cross sectional area **equal to 10mm^2** due to the drive leakage current. The mains PE is connected to M4 screw terminal at either end of the drive heat sink.



The protective earth conductor

In multiple drive installations, each drive must be individually wired to a common PE point. Do not daisy chain PE connections from one drive to the next.

The AMD2000 drive is designed to be installed on an unpainted metal gear tray e.g. galvanized surface which forms an equipotential bond to all equipment mounted on the same gear tray. This minimizes voltage differences to all grounded connections and enhances the immunity of equipment against conducted and radiated RF disturbance. The gear tray must be connected to the supply PE, and is designated the Chassis Earth.


Symbol for Chassis Earth

6.5 Input EMC (Electromagnetic Compatibility)

EMC stands for Electromagnetic compatibility. It is the ability of electrical/electronic equipment to operate without problems within an electromagnetic environment. Likewise, the equipment must not disturb or interfere with any other product or system within its locality. Variable speed drives are a source of interference, and all parts which are in electrical or airborne connection within the power drive system (PDS) are part of the EMC compliance.

The drive interference is generated from the output voltage waveform which is a rapidly changing voltage waveform (Pulse Width Modulation). The voltage transitions present on all motor cables and motor windings

induce parasitic common mode currents (I_{LEAK}) in the stray capacitance of the motor and cable system. See *Figure 6-4.* The common mode currents return to the drive inverter by lowest available impedance paths which must be carefully managed to prevent interference voltages being generated to other equipment connected to the same earth system. Internal common mode capacitors of the drive provide one return path (I_{DC}) to the drive, and the EMC filter provides another return path via the drive mains input.

A correctly sized EMC filter limits the high-frequency harmonic effects on the supply systems of the drive by reducing the conducted emissions in the frequency range between 150 kHz and 30 MHz. The EMC filter ensures that disturbances produced by the drive are mainly kept inside the drive system itself and that only a small percentage (within the permissible tolerance range) can spread into the supply system. *Figure 6-4* shows a variable-speed drive system which comprises a cabinet-mounted AMD2000 drive which is supplying a motor via a shielded motor cable. Common mode currents can also return to the supply transformer star point where the PE is bonded to supply phase lines. Thus EMC currents may affect other equipment connected to the same Point of Common Coupling (PCC).

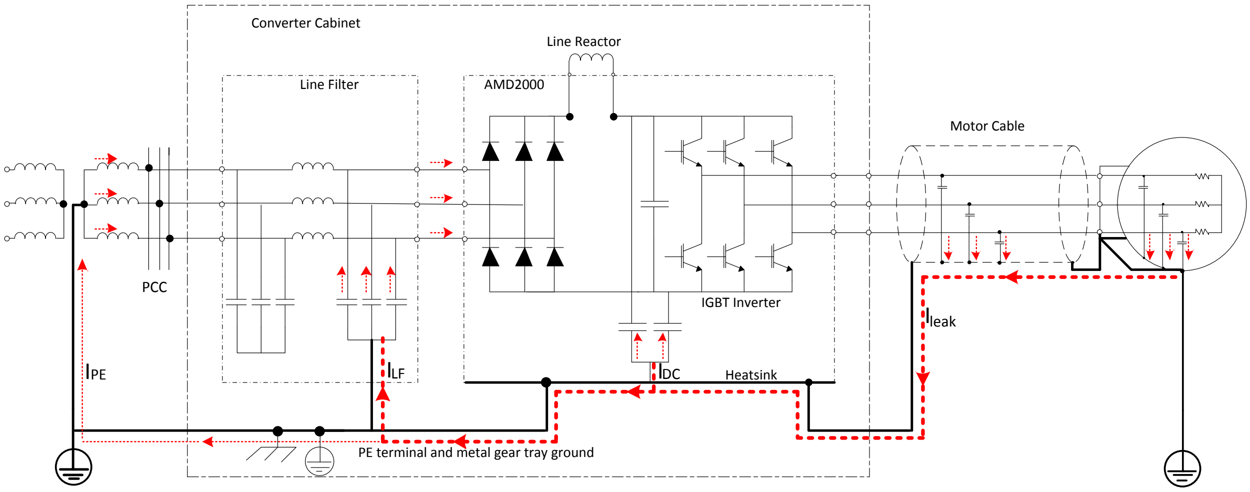


Figure 6-4 Common Mode Noise Current Paths in a Drive System

6.5.11 EMC Filter Specifications

To ensure the installation meets the emission standard for power drive system IEC61800-3 the correct EMC filter on the mains supply must be used.

Recommended EMC filters for mains power and control supply	
AMD2000, 3A & 9A 3 phase supply	Schaffner 3-phase 10A EMC Filter FN3270H-10-44
AMD2000, 1 phase control supply	Schaffner 1-phase 1A EMC Filter FN 343-1-05

Meeting the requirements of IEC61800-3 depends on the drive installation configuration and all of the guidelines below must be followed. If no EMC filter is installed then the drive may cause interference to the drive control system and to other nearby electronic equipment. Note that interference can be from both conducted emission and radiated emission. An EMC filter also improves a system's resistance to interference from external sources at the point of common coupling

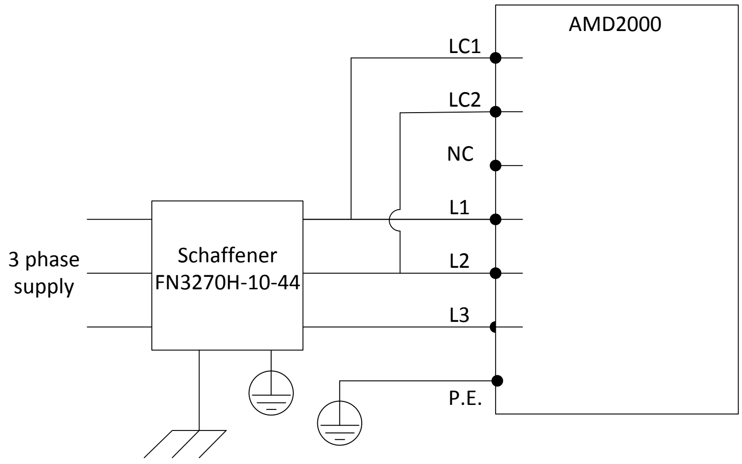


Figure 6-5: EMC filter installation for 3 or 2 phase supply

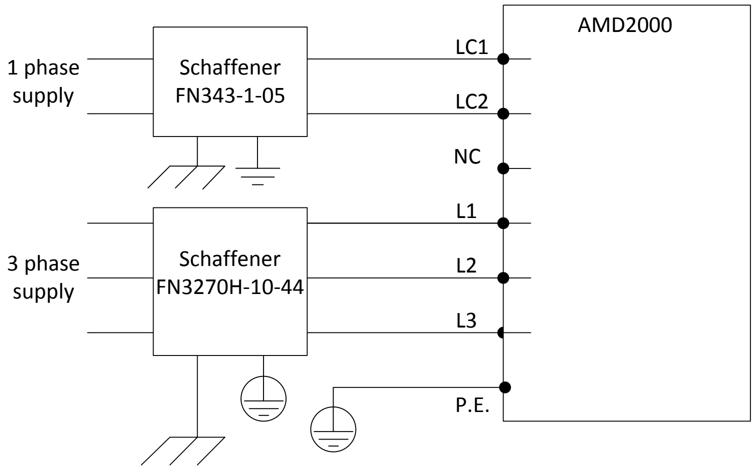


Figure 6-6: EMC filter installation for separate control supply

6.5.12 Installation guidelines of EMC filter

- Install the EMC filter as close as possible to the AMD2000 drive.
- A shielded cable is recommended if the distance between mains filter and drive exceeds 30cm.
- Minimize cross talk of “clean” lines (mains supply to filter input) to “noisy” power cables by careful routing and cable segregation.
- Ensure filter is installed on an unpainted metal gear tray to provide a low impedance return path. Otherwise connect filter to gear tray with minimal length flat copper braid strap
- Connect the filter to PE for safety requirements, but note that PE cable does not provide a low impedance return path for common mode currents due to cable length and skin effect of conductors. Best EMC equipotential bonding is achieved using careful mounting or use of braided earth straps.
- Minimize motor cable length, and use correctly shielded motor cables. For longer cable lengths a ferrite ring on the drive output will reduce EMC noise
- Ensure that the EMC filter is used with a mains line inductor to reduce rms currents. Otherwise the current rating of the EMC filter may be exceeded.

6.6 Power Supply Filters

6.6.11 Harmonic Suppression

IEC 61800-3-2 specifies limits on the amounts of conducted harmonic emissions (current) from electrical equipment connected back into the electricity supply.

The drive has two terminals P1 and P2 across which a user may place an inductor (choke) to limit emissions for compliance to the standard above or simply to ensure a cleaner local supply. Note that by increasing the size of the choke the conducted emissions will be less, but the power output available may drop. If an inductor is placed between terminals P1 and P2 on X2, it shall be designed to drop less than 5% of the line voltage

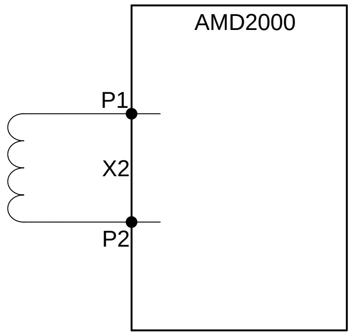


Figure 6-7 Typical Example of an Inductor/Choke Connection at P1 and P2

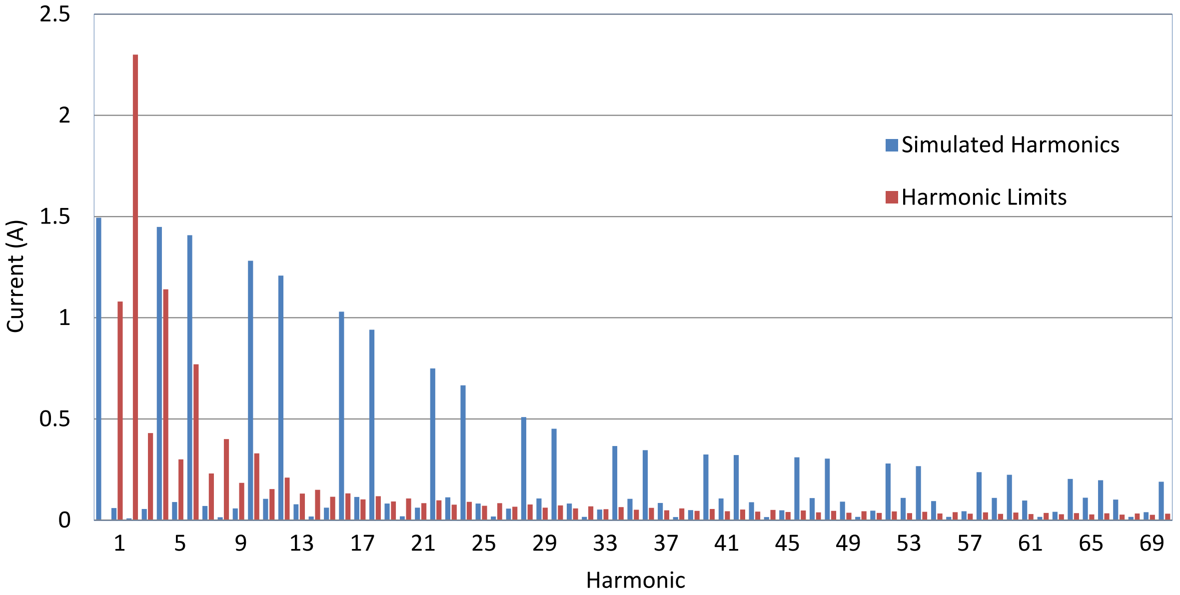
If no choke is to be used, a suitable link must be installed at P1 and P2 on provided connector to power the motor

At 3A rms on the AMD2000 3A, 10mH of inductance is required. A suitable device may be Hammond Manufacturing 159J.

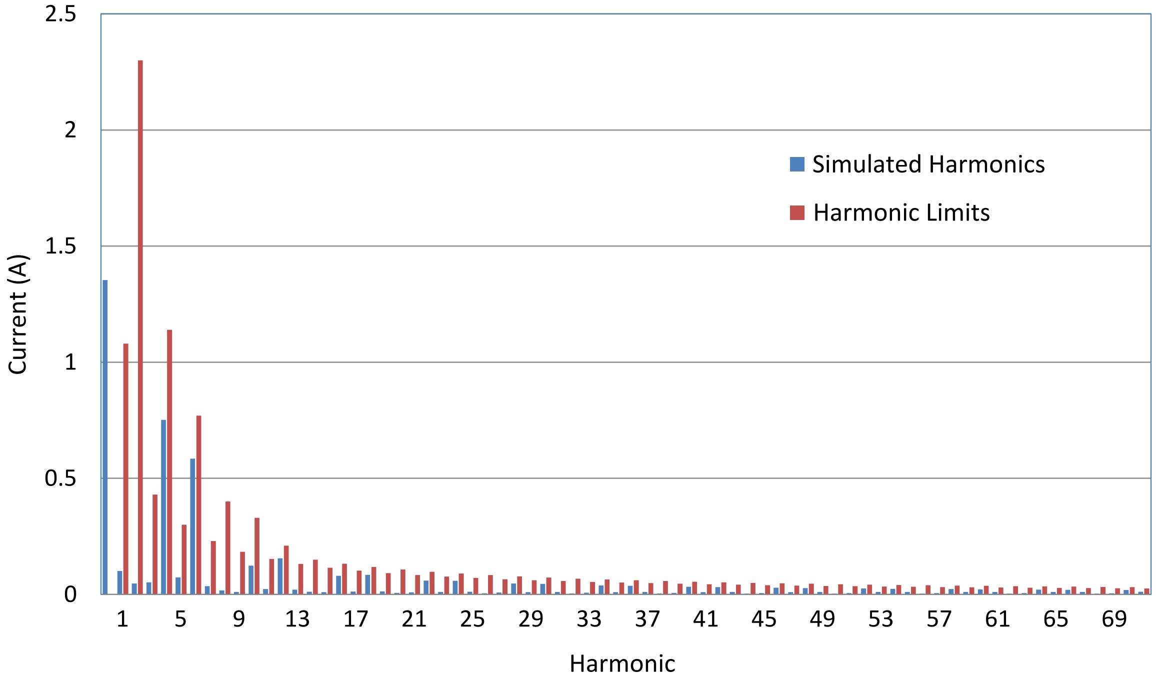
AS 61000-3-2 defines equipment over 1kW for use in industrial environments as Professional Equipment, and there is no requirement by the standard for the user to limit the conducted harmonic current emissions. As the minimum power output of the AMD 9 is over 1kW ANCA Motion does not recommend an inductor for this purpose, however if a user wishes to reduce harmonics for better local mains supply condition then an inductor no greater than 10mH for a three phase AC (supply side not armature side) line reactor is recommended. Note that the power output from the drive will decrease as the inductor size increases. However the drive will have reduced stress on the bus capacitors, resulting in a longer lifespan.

Example :

Drive harmonics on a AMD2000 3A drive without Inductor



Drive harmonics for above drive with inductor

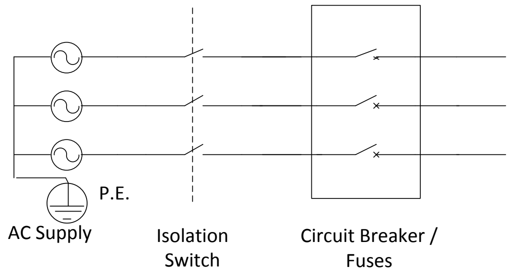


6.7 Power Disconnect and Protection Devices

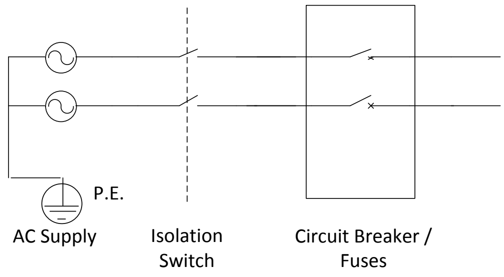
Install a hand-operated mains supply disconnecting device between the AC power source and the drive. The disconnecting device must be of a type that can be locked to the open position for installation and maintenance work, and must comply to Safety of Machinery standard EN 60204-1 and local regulations.

The AMD2000 must have suitable input power protection on each phase input. Fast semiconductor fuses are preferable to circuit breakers.

3 Phase Supply

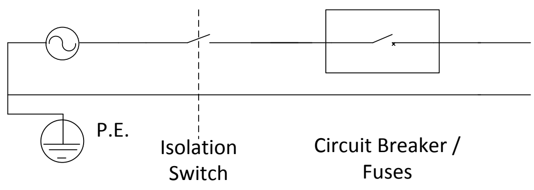


2 Phase Supply



When using 2 phases of a 3-phase supply each phase must have suitable protection and the voltage must not exceed the rated input voltage.
When using a single phase supply with a Neutral conductor, protection is only required on the supply phase.

1 Phase Supply + Neutral



Recommended fuse and circuit breakers, and supply/motor wire sizes					
Drive Type and current output rating (A rms)	**AC supply**	**Input fuse**	**Circuit breaker (C-type)**	**Minimum *Φ* wire gauge**	
				AWG	**mm²**
AMD2000, 3A	1Φ power	Ferraz Shawmut: 6x32 FA series, 10 A (W084314P)	10A	14	2.5
	3Φ power	Ferraz Shawmut: 6x32 FA series, 8 A (V084313P)	8A	14	2.5
	1Φ control	Ferraz Shawmut: 6x32 FA series, 1A (K084304P)	1A	20	0.5
AMD2000, 9A	1Φ power	Ferraz Shawmut: BS88 2.5 URGS, 25 A (R076651J)	25A	14	2.5
	3Φ power	Ferraz Shawmut: 6x32 FA series, 20 A (A084318P)	20A	14	2.5
	1Φ control	Ferraz Shawmut: 6x32 FA series, 1A (K084304P)	1A	20	0.5

Note: All wire sizes are based on 75 °C (167 °F) copper wire. Use of higher temperature cable may allow smaller gauge wires. Size cables to conform to the local electric installation regulations.

Recommended fuses are based on 25 °C (77 °F) ambient, maximum continuous control output current and input harmonic inductor fitted. Use fast acting fuses with high breaking capacity (200kA), 250V or more rating.

- The mains supply wire should be used for the following power connections:
  - AC supply to external EMC filter (when used)
  - AC supply (or external EMC filter) to drive
- Cable sizes are a guidance only as installation methods such as grouping, length, use of conduits and ambient temperature may affect current capacity
- The power supply terminals are designed for a cable size of AWG 24-14 (0.2-2.5 mm^2)
- Where more than one cable per terminal is used the combined diameters should not exceed the maximum.
- The terminals are suitable for both solid and stranded wires.
- Use fast acting fuses with high breaking capacity (200kA), 250V or more, and low I^2t rating to protect the semiconductor input of the drive
- The I^2t rating of the Circuit Breaker must be less than or equal to that of the fuse rating listed above
- Circuit Breakers must be thermal magnetic type.
- Motor cables should have the same wiring gauge as 3 phase mains supply

6.8 Motor Connections

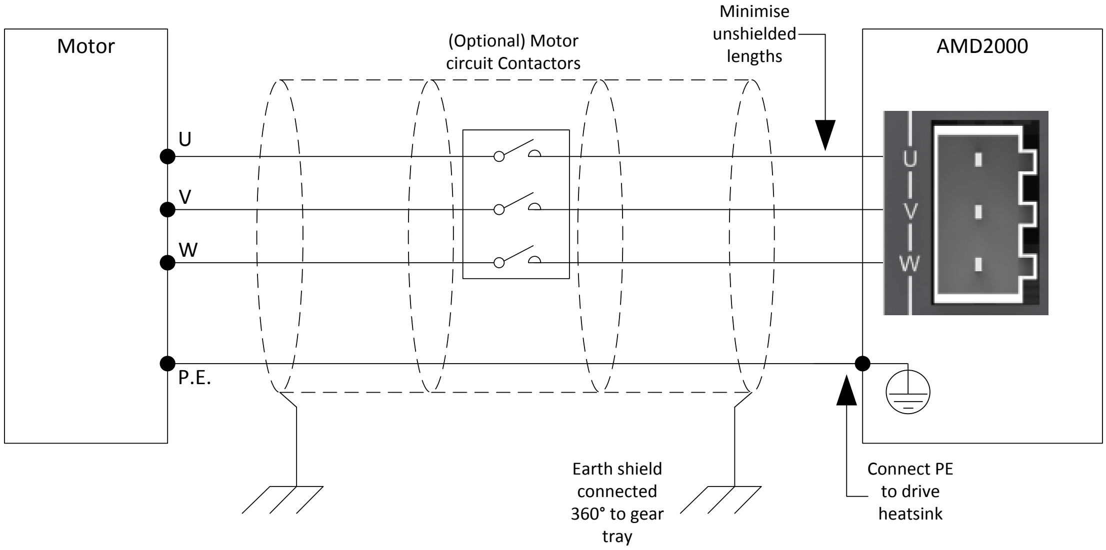


Figure 6-8: Motor connections and shielding

Connect correct phase wires (U, V, W) to the servo motor to ensure the servo motor operates correctly.

Do not connect AC mains power supply directly to the drive terminals, otherwise damage may occur to the drive.

The PE ⏚ for the motor must be connected to the M4 screw terminal at one end of the drive heat-sink, preferably at the end closest to the armature motor connector. Do not connect directly to the mains supply protective earth as this will increase EMC noise.

6.8.11 Motor Circuit Contactors

A motor circuit contactor may be installed if required by local codes or for safety reasons. The motor circuit contactor isolates the motor fully from the drive to allow maintenance and form part of a safety system.

Ensure that shielding of the motor cable is continued on both sides of the motor circuit contactor as shown in *Figure 6-8.*

6.8.12 Motor Power Cable Installation

6.8.12.1 Cable shielding

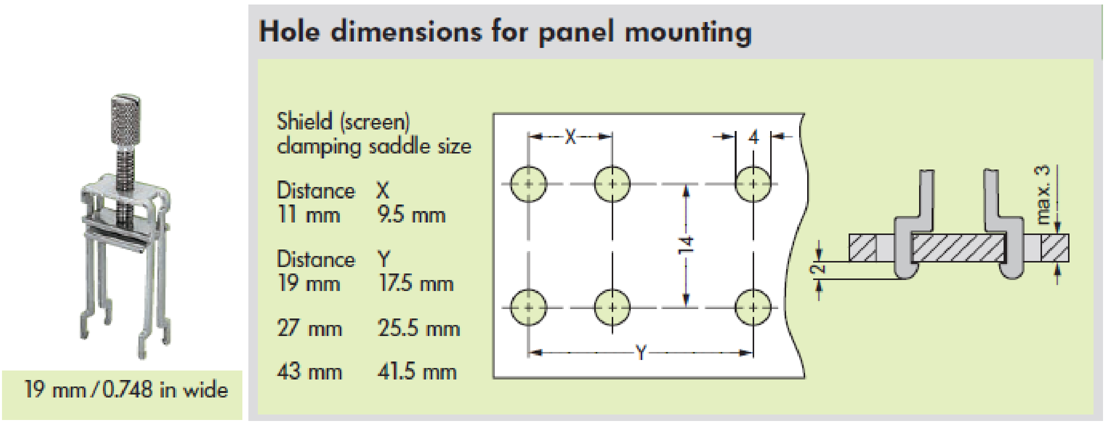
In order to comply with the EMC requirements and minimize affects to other equipment, motor cables and power supply cables from line filter AMD2000 drive must be used with shields. The cable shield minimizes electromagnetic noise which may be coupled into nearby conductors, and the shield provides a low impedance path for common mode noise currents back to the drive via EMC filter or drive common mode capacitors. See *Figure 6-4* which illustrates the path of common currents. The gear tray layout and correct bonding of the shield in the cabinet is a critical component in managing EMC problems. The following guidelines must be followed.

- Cables between the inverter and motor must be shielded, and the shield grounded at both ends.
- Use motor cables with dedicated PE conductor(s). Do not use the shield as a PE.
- The shield clamping surface must be free of paint
- Use specifically designed shield clamps. Do not use plastic ties!
- Select shield connections with low impedance in the MHz range.
- Shield clamps can be with or without mechanical strain relief
- Metallic components in the gear tray and cabinet must have a large surface area and should be connected to one another with a high level of RF conductivity.

6.8.12.1.1 Installation of the EMC Clamp on Shielded Armature Cables

6.8.12.1.2 AMD2000 3A Drive

- Use a saddle clamp to terminate the shielded armature cable to gear tray.
- WAGO Part Number 790-116
- Use the following footprint specifications for drilling into the gear tray. Drill the holes as close as possible to the drive as shown below.
- Clamp the exposed braid by turning the knurled screw and tighten to 0.5Nm to complete the connection.



Expose approx. 25mm of the cable sheath and feed the armature cable between the holes in the gear tray.

Install the saddle clamp so that the exposed braid can be clamped down to the gear tray. Clamp the exposed braid by turning the knurled screw and tighten to 0.5Nm to complete the connection.

Fit the armature plug into the armature connector on the drive.

Ensure that the Armature Cable Earth wire is connected to an M5 ring lug or M5 spade lug and connect to the heat sink.

There are two earthing points on the heat sink. Install the Protective Earth Wire to the upper earthing point, and the Armature Cable Earth Wire to the lower earthing point. See below pictures.

Maximum tightening torque is 1.5Nm.

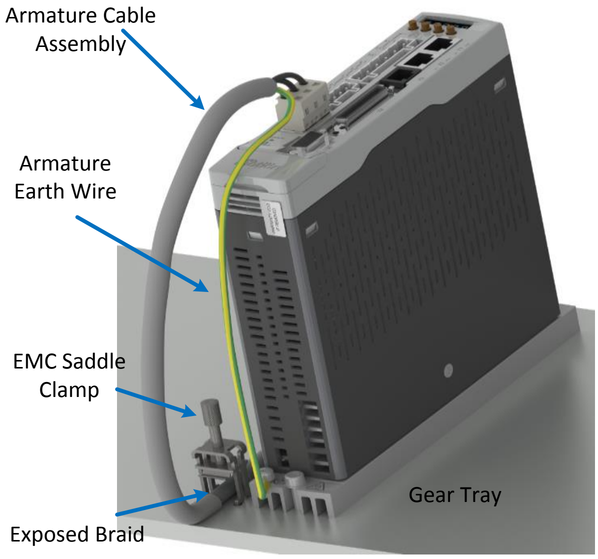


Figure 6-9 Armature Cable Shield Connection

Figure 6-10 AMD2000 D2003 Drive Protective Earth Connection

6.8.12.1.3 AMD2000 9A Drive

Use an Armature Bracket in order to terminate the shielded cable assembly.

The Armature Termination Bracket assembly consists of the following parts :

1. Armature Termination Bracket
2. EMC Saddle Clamp
3. 2 x M5 screws

Please see accessories section for bracket ordering details. *13.4.13 Armature Shield Clamping Brackets*

- Clamp the Armature Termination Bracket down as shown below using the 2 x M4 screws. Tightening Torque 2.5Nm max.
- Carefully remove the Armature cable sheath to expose the metal braid. Expose approximately 25mm of braid length.
- The position of the exposed braid is to coincide with the EMC Saddle Clamp and the metal bracket as shown below in order to provide sufficient contact for termination.
- Tighten the Saddle Clamp screw to 0.5Nm as recommended by the manufacturer.
- Fit the armature plug into the armature connector on the drive.
- Ensure that the Armature Cable Earth wire is connected to an M5 ring lug or M5 spade lug and connect to the bracket as shown below. Maximum tightening torque is 1.5Nm.

See below for the interactions for the shielded armature termination.

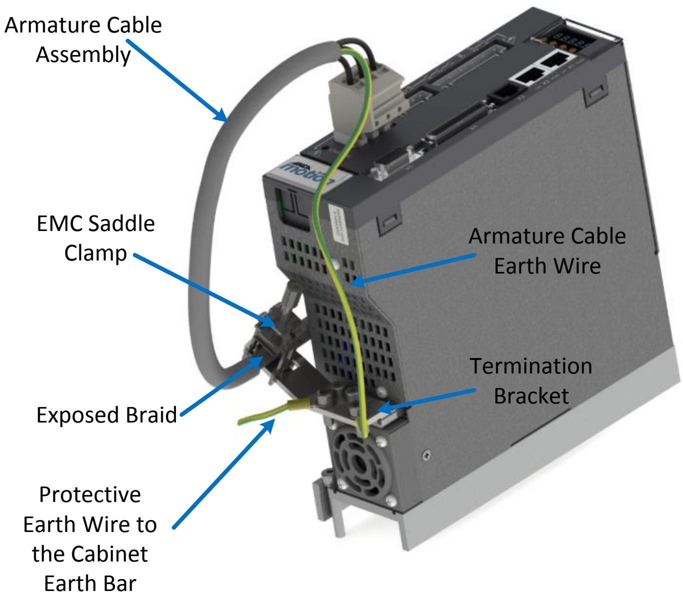


Figure 6-11 AMD2000 D2009 Drive Shield and Protective Earth Connection

6.8.12.2 Continuation of Motor Power Cable Shielding

- Add a metal P-Clip or equivalent to the armature cable at a location that is close to the motor for earthing the shield.
- In order to add this part to the Armature Cable, remove a sufficient amount of outer sheath in order to make direct contact with the exposed metal braid.
- Ensure that the metal braid is not damaged in this process.
- Remove the painted to expose the bare metal beneath. The shield is required to have a good electrical connection to the machine earth.

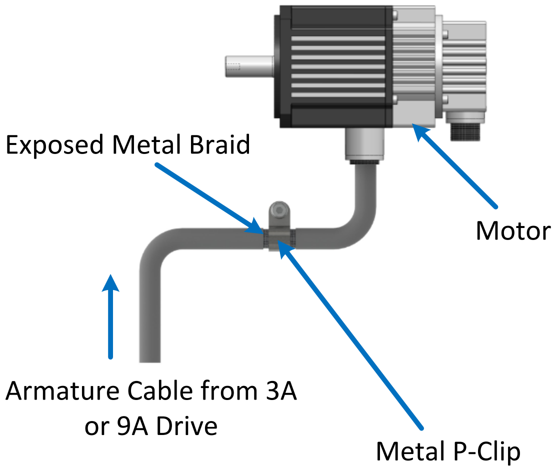


Figure 6-12 Armature Cable Shield Termination at Motor End

The below graphic shows a typical Earth Bar installation that may exist on the cabinet. Connect the Protective Earth wires to the Earth bar as shown. Each protective earth Wire will be from a drive in the cabinet.

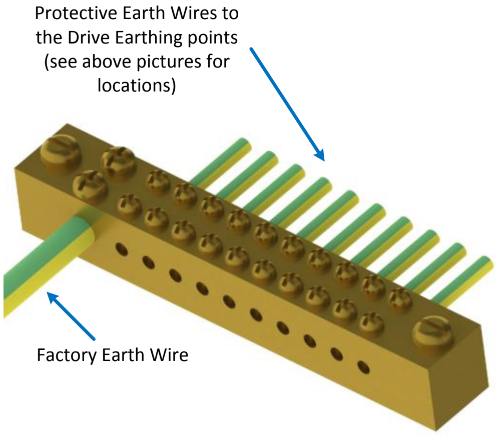


Figure 6-13 Use Start Topology to Connect Drive Protective Earth to Earth Bar

6.8.12.3 Cable routing

In a drive system the return common mode currents flow through shields, cabinets, gear tray and earth wiring to create localized parasitic ground potentials, which may affect control signals using the ground as a common voltage reference. Careful planning of cable routing and location of shield grounds must be done to minimise influence of parasitic ground potentials, and ensure compliance with EMC requirements. The following guidelines must be followed.

- Physically separate “noisy” and “clean” cables at the planning stage. Pay special attention to the motor cable. The area around the shared terminal strip for the mains input and motor output is particularly at risk.
- All cable routing in an enclosure should be as mounted close as possible to gear tray or grounded cabinet walls; “free-floating cables” act as both active and passive antennae
- Use twisted pair wires wherever possible to prevent interference from radiated common mode noise sources. Continue the twist as close as possible to terminals.
- Use shielded twisted pairs for analogue and control level wires exiting from the overall enclosure.
- Keep power and control wiring separate. Crossing at right angles is permitted, but no significant parallel runs should be allowed, and cables should not share cable trays, trunking or conduits unless they are separately shielded and the shields correctly terminated
- Avoid mixing pairs with different signal types e.g., 110 V AC, 230 V AC, 24 V DC, analogue, digital.
- Run wires along the metal surface and avoid wires hanging in free air, which can become an antenna.
- If plastic trunking/ducting is used, secure it directly to installation plates or the framework. Do not allow spans over free air which could form an antenna.
- Keep shield pigtails as short as possible and note they are less effective than full clamping
- Allow no breaks in the cable shields.
- Earthing connections should be as short as possible in flat strip, multi-stranded or braided flexible conductors for low RFI impedance.
- When an EMC enclosure is to be used, the maximum diagonal or diameter for any hole is 100 mm, which equates to 1/10th of the wavelength of a 300 MHz frequency. Holes bigger than 100 mm must be covered with a metal frame surrounding the aperture and earthed to the enclosure.

6.9 Drive Output Filters

6.9.11 Sinusoidal Filter

Sine-wave filters are designed to let only low frequencies pass. High frequencies are consequently shunted away which results in a sinusoidal phase to phase voltage waveform and sinusoidal current waveforms. Sine wave filters are recommended for the following applications:

- Reduction of motor acoustic switching noise
- Motors that are not “inverter rated” which have reduced insulation levels and can only accept sinusoidal inputs supplies
- Retrofit installations with old motors that are not “inverter rated”
- Motors that require reduced bearing currents to prolong motor life and reduce service intervals
- Step up applications or other applications where the frequency converter feeds a transformer

Note: Sine-wave filters must be selected for the drive switching frequency of 8kHz. Sinusoidal filters with nominal frequency higher than 8kHz cannot be used.

Standard Sinewave filters are connected to the drive output as shown in *Figure 6-14*. For more demanding applications, Sinewave filters with DC bus connections can also be used as shown in *Figure 6-15*. There is an output voltage drop of approximately 5-10% across the sinusoid filter.

Recommended Sinusoidal filters	
AMD2000, 3A, with no DC bus connection	Schaffner 3-phase 4A Sinewave and EMC Filter FN 520-4-29

AMD2000, 3A, with DC bus connection	Schaffner 3-phase 4A Sinewave and EMC Filter with DC bus link FN 530-4-99
AMD2000, 9A, with no DC bus connection	Schaffner 3-phase 12A Sinewave and EMC Filter FN 520-12-29
AMD2000, 9A, with DC bus connection	Schaffner 3-phase 12A Sinewave and EMC Filter with DC bus link FN 530-12-99

Note: Motor frequency range is from 0-200Hz for these filters

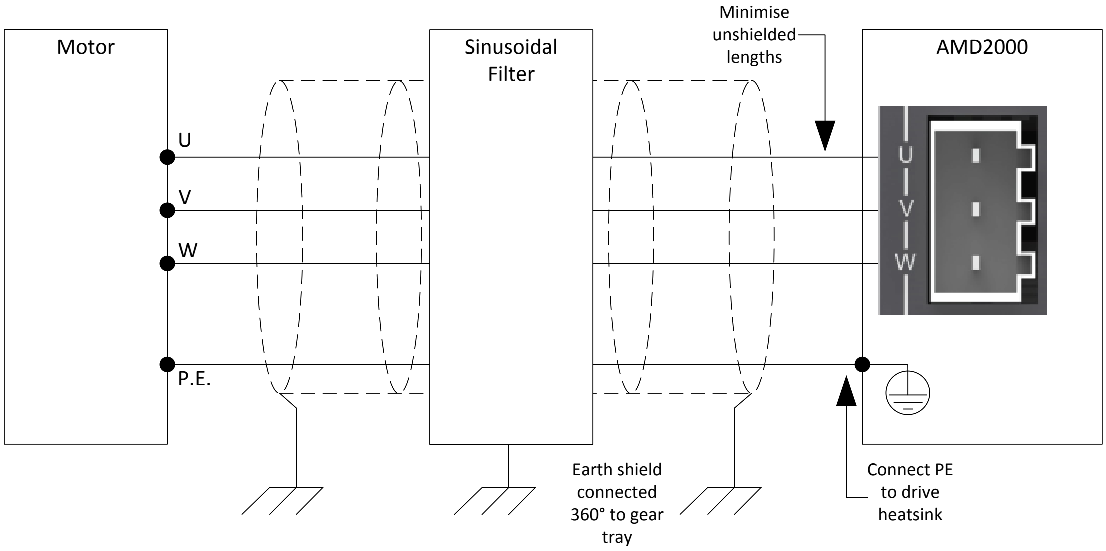


Figure 6-14: Motor Connections and Shielding with Standard Sinusoidal Filter

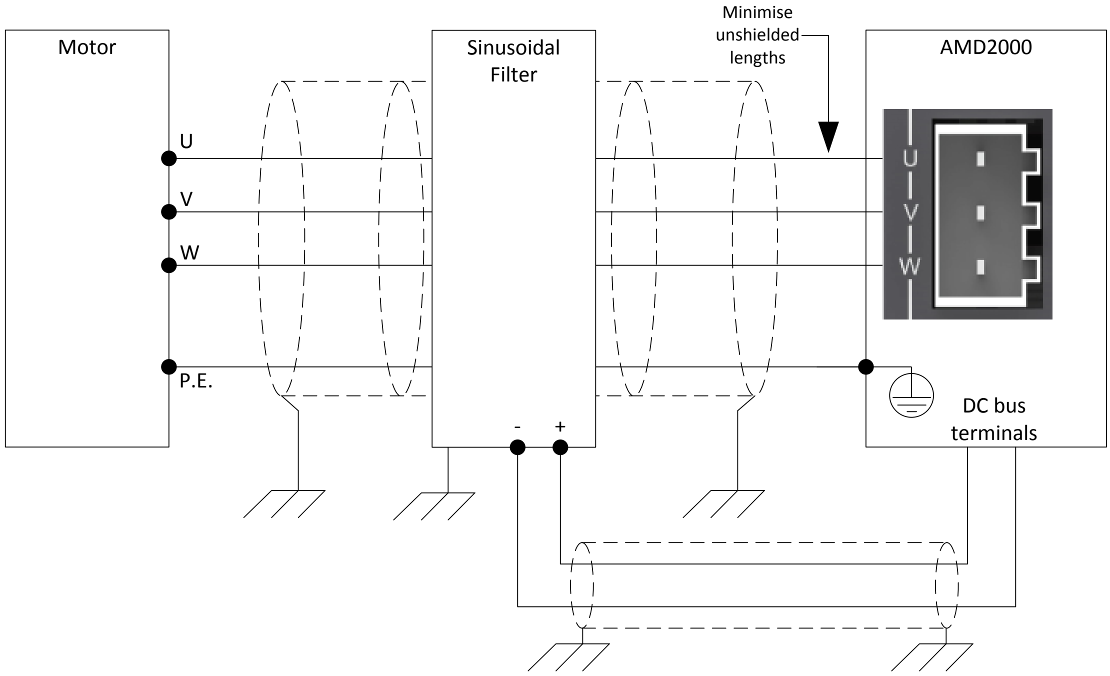


Figure 6-15: Motor Connections and Shielding and DC Link Sinusoidal Filter

6.9.12 du/dt Filter

The du/dt filters consist of inductors and capacitors in a low pass filter arrangement and their cut off frequency is above the nominal switching frequency of the drive. Compared to Sine-wave filters they have lower L and C values, thus they are cheaper and smaller, and have less voltage drop (approximately 0.5%). With a du/dt filter the voltage wave form is still PWM shaped but the current is sinusoidal. The reduced performance of the du/dt filter compared to the sinusoid filter makes it unsuitable for motor bearing current reduction and acoustic noise reduction.

6.10 Motor Brake Connection

Some motors require the use of a brake to prevent motor movement when power is removed. The motor's brake must be wired up to a relay which is controlled by the 24V digital output 1 (DO1), on connector X4. The relay must be wired with a protective fly-back diode as shown to prevent damage to the drive 0V supply.

IDN 33346 is the state of the motor brake control:

- 1: motor brake released
- 0: motor brake engaged

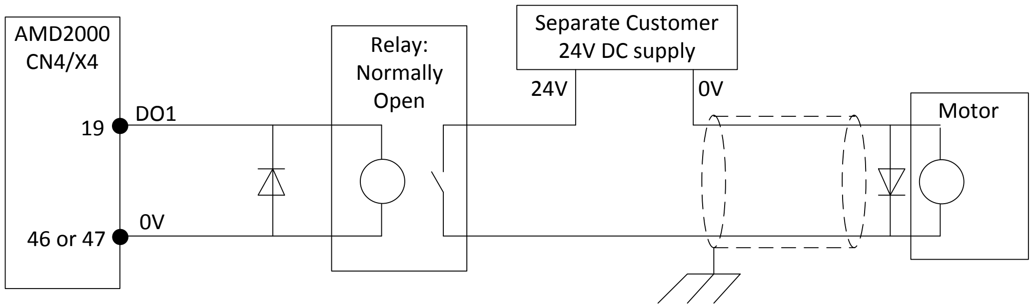


Figure 6-16: Motor Brake Interface Circuit

To engage the brake:

- The motor is brought to rest under normal control;
- The relay is deactivated, causing the brake to engage;
- The drive is disabled, removing power from the motor.
-

To disengage the brake:

- The drive is enabled;
- The drive applies power to the motor to hold position under normal control;
- The relay is activated, causing the brake to be disengaged.

It is sometimes necessary to include a small delay after the relay has been activated, before starting motion. This delay allows time for the relay contacts to engage and the brake to release.

The 24V DC power supply for the brake must be a separate supply as brake wires often carry noise, and generate a large voltage spike which may affect other devices connected to the brake supply. Do not use the AMD2000 24V supply from X4 to power the brake. The separate 24 V DC supply used for the motor brake can also be used to power the relay in the thermal switch circuit.

6.11 Motor Thermal Switch

Some motors provide thermal switch to prevent the motor overheating. The motor's thermal switch must be wired up to a relay which generates a 24V digital input on connector X4. Any of digital inputs DI-01 to DI-08 may be used and DI-01 is shown in *Figure 6-17*. The status of all digital inputs DI-01 to DI-08 can be monitored with IDN 33343 where bit 0 is the first digital input, bit 1 is the second digital input, etc. The IDN 33343 can be monitored by an external CNC.

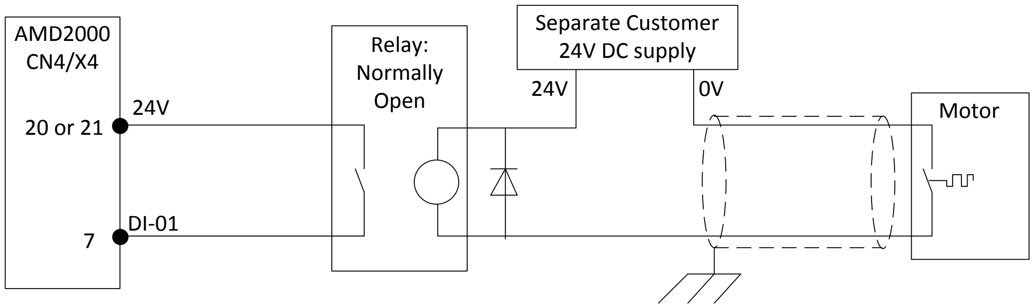
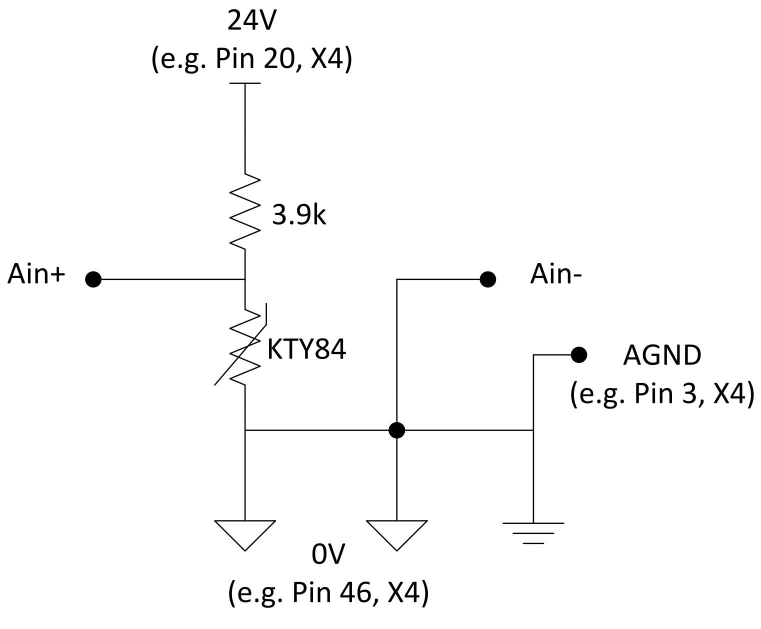


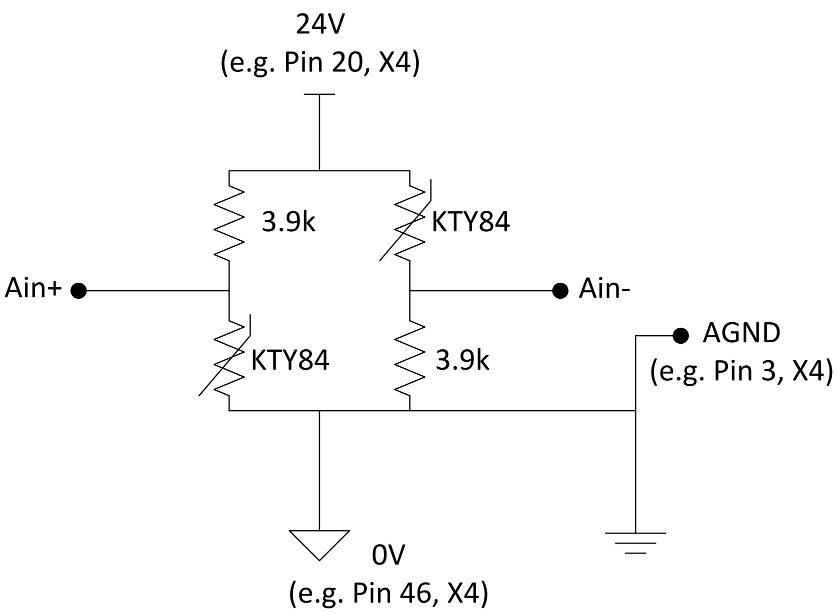
Figure 6-17: Motor Thermal Switch interface circuit

The 24V DC power supply for the thermal switch must be a separate supply as it can often carry noise that could cause erratic drive operation, and may not provide sufficient isolation. Do not use the AMD2000 24V supply from X4 to power the thermal switch. The separate 24 V DC supply used for the thermal switch can also be used to power the relay in the brake circuit.

6.12 Motor Thermal Sensor

Some motors provide a thermal sensor to give feedback of motor temperature. This model of drive does not feature a dedicated analogue input for this function. If using an external CNC, the motor thermal sensors can be connected to one of the drive analog inputs by means of a voltage divider or two voltage dividers as indicated in the diagrams and have the monitoring implemented in the CNC. The user is then responsible for converting the non-linear voltage output from the circuit into an equivalent temperature for the temperature sensor selected. Two temperature sensors are recommended as in diagram (x) in a bridge configuration instead of one sensor. The reasons for this is increased noise immunity because there is twice as much voltage per degree of temperature change, and also because the voltage feeding the divider does not affect the measurement. If this configuration is used the temperature sensors must be co-located; that is they must be in approximately the same physical location.





6.13 Brake/Regeneration Resistor

The AMD2000 3A and AMD2000 9A drives feature an inbuilt regeneration resistor. Regeneration refers to the process whereby when the motor is actively providing energy to the drive and then stops, the kinetic energy in the entire mechanical system connected to the shaft of the motor gets transferred to the bus capacitance in the drive, which increases the voltage. This happens because of the motor inductance. When the voltage on the bus capacitance exceeds 385V the drive will connect the internal regeneration resistor in addition to any external regeneration resistor that is provided by the user.

Mode	Connection
Internal Regeneration Resistor	Link pins P & D
External Regeneration Resistor	Connect resistor to P & C

Danger: Do not short circuit connector P to C. Connector P is live with active high voltage.

Please refer to sections *12.5.14 Regenerative Braking* and *12.14 Brake/Regeneration Resistor* for additional information.

7. Control Wiring

DANGER - The working DC bus is live at all times when power is on. The Main Isolator feeding the drive must be switched to the **off** position at least 15 minutes before any work is commenced on the unit. The operator must check the bus voltage with a tested working voltage measuring instrument prior to disconnecting any connectors or opening the DC Bus terminal cover. The red LED indicator on the front of the drive which indicates that there is charge remaining in the drive is only to be used as an aid to visual troubleshooting. It shall not be relied on as a means of safety.

Do not plug or unplug connectors while power is applied. It is recommended that the drive is installed with an upstream circuit breaker that is rated appropriately depending on the model of AMD2000 drive being installed.

Turn the Main Disconnect mains isolator switch to the Off position.

Following the appropriate lockout procedure, place a sign over the isolation switch clearly indicating to other personnel that this isolator is not to be touched.

7.1 What this Chapter Contains

This chapter contains information related to interfacing of the drives to the following connections:

- Analog and Digital I/O
- EtherCAT
- Motor Feedback

7.2 Analog I/O

All analog Input and Output signals are connected to drive via X4 with the following pins,

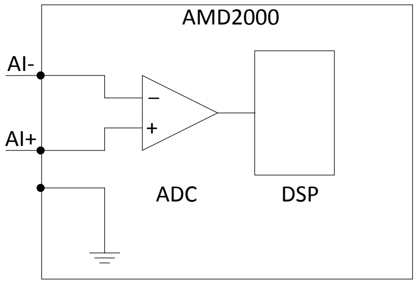
<table>
<tr><th>Connector</th><th>Pin Number</th><th>Label</th></tr>
<tr><td rowspan="6">X4
or
I/O Module</td><td>1</td><td>AI-01 +</td></tr>
<tr><td>26</td><td>AI-01-</td></tr>
<tr><td>2</td><td>AI-02 +</td></tr>
<tr><td>27</td><td>AI-02-</td></tr>
<tr><td>28</td><td>AO-01</td></tr>
<tr><td>3, 4, 30, 31</td><td>AGND</td></tr>
</table>

Please refer to section *12.3 Interface Specifications* for detailed specifications

7.2.11 Analogue Inputs

The analog inputs pass through a differential buffer and second order low-pass filter with a cut-off frequency of approximately 1.3 kHz.

7.2.11.1 Idealised drawing of Analog Input Circuit



7.2.11.2 Typical Connection Examples of Analog Input

Single Ended (Ground Referenced) Connection.

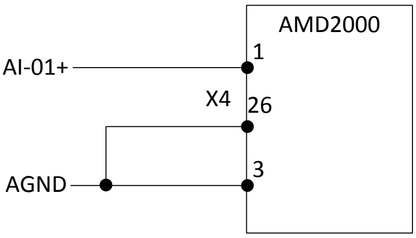


Figure 7-1 Typical Example of Single Ended Connection

For differential inputs connect lines to AIN+ and AIN-. Leave AGND unconnected.

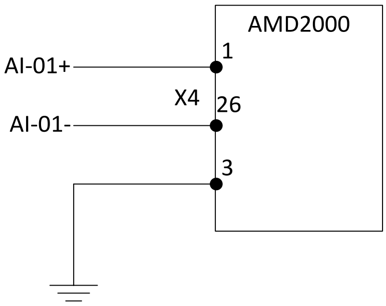


Figure 7-2 Typical Example of Differential Connection

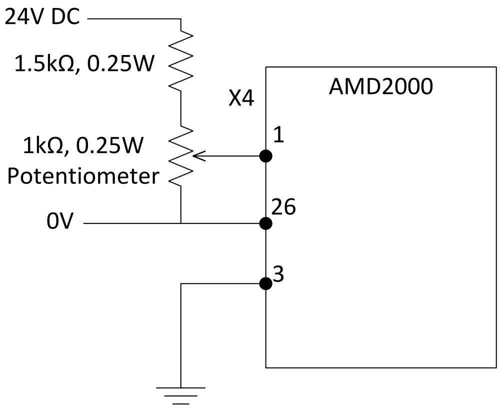


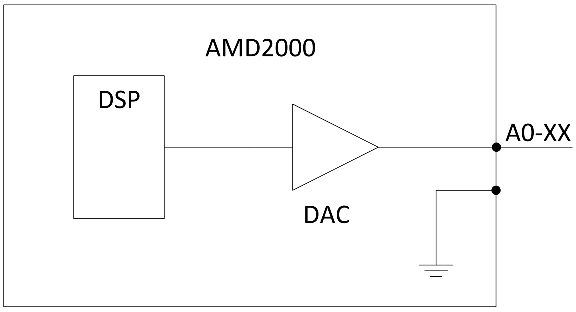
Figure 7-3 Typical Input Circuit to Provide 0-10V Input From a 24V Source

7.2.12 Analogue Outputs

A0 -1 can be used to output converted analog values of digital measurements recorded in the drive.

It is recommended that shielded twisted pair cable is used for interfacing. The shield connection should be made at one end only.

7.2.12.1 Idealized Drawing of Output Circuit



7.3 Digital I/O

All digital Input and Output signals are available via connector X5. The AMD2000 provides:

- 8 x General Purpose Inputs
- 2 x additional General Purpose Inputs can be configured if required
- 6 x General Purpose Outputs

Please find details specifications in section *12.3 Interface Specifications*

Connector	Pin Number	Label
X4 or I/O Module	7	DI-01
	8	DI-02
	9	DI-03
	10	DI-04
	11	DI-05
	12	DI-06
	13	DI-07
	14	DI-08
	15	DI-09+
	16	DI-09-
	17	DI-10+
	18	DI-10-
	19	DO-01
	22	DO-02
	23	DO-03
	24	DO-04
	25	DO-05
	34	DO-06
	20, 21	+24V-Fused[1]
	46, 47	+24V-GND

[1] Refer to the AMD2000 *Technical Data* for maximum current rating

7.3.11 24V Control Circuit Supply

The maximum current that can be drawn from this supply is 500mA total. Note that if a motor with a brake is required this may be insufficient current to release the brake, so an external power supply will be required. Also note that if overloaded the polyfuse in the drive will present a high resistance and there will no longer be 500mA available until the load is removed.

7.3.12 Digital Inputs

Digital Input Overview

- DI-01 – DI08 are electrically isolated through opto-couplers.
- DI-09 – DI10 are not isolated.
- Reference ground is +24V-GND (X4 pins 46 & 47)

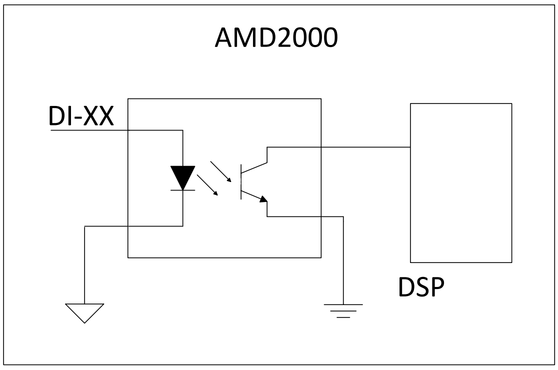
Application examples for the digital inputs includes:

- Positive Limit switch
- Negative Limit switch
- Motor over-temperature
- Home switch

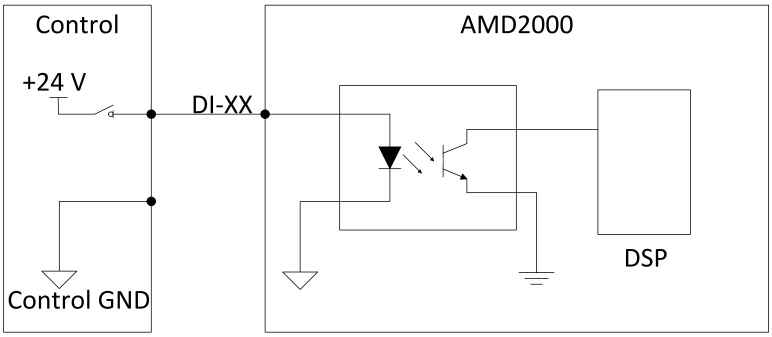
7.3.12.1 General Purpose Digital Inputs DI-01 to DI-08

Warning: Please refer to section *12.3 Interface Specifications* for detailed current ratings of the 24V supply if used to switch I/O devices

7.3.12.1.1 Idealized Drawing of Input Circuit



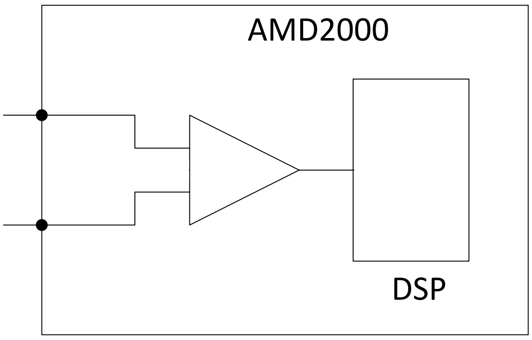
7.3.12.1.2 Typical Connection Example



7.3.12.2 Differential Inputs DI-09 & DI-10

Section 12.3 Interface Specifications provides detailed information on these two RS 422 inputs. If 2 additional digital inputs are required this may be done safely via optional I/O interface Module accessory listed in *13.4.11 I/O Interface Accessories*

7.3.12.2.1 Idealized Drawing Of Differential Input Circuit



7.3.12.2.2 Typical Connection Examples of this special purpose circuit are found below.

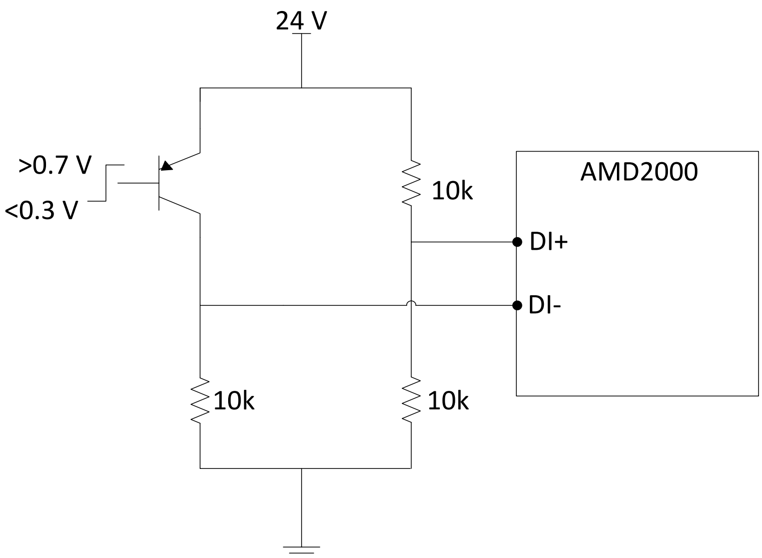


Figure 7-4 - PNP Example

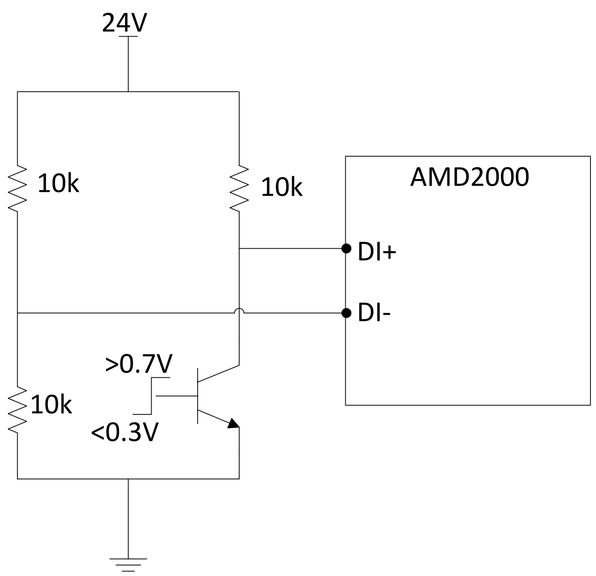


Figure 7-5 - NPN Based Sensor

7.3.12.3 Digital Outputs

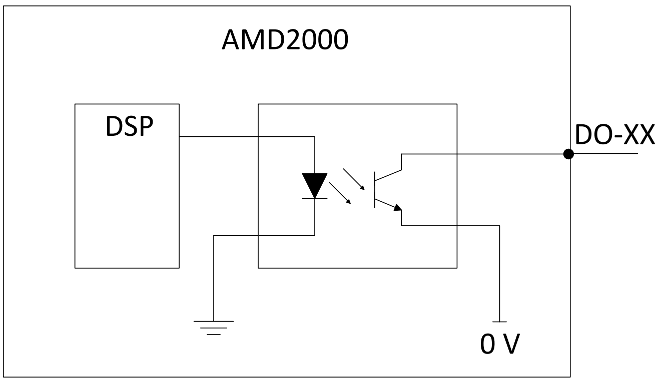
The digital outputs can be used to output pre-programmed functions stored in the drive. Programmable function of the digital outputs includes:

- Relay Control

Digital Output Overview

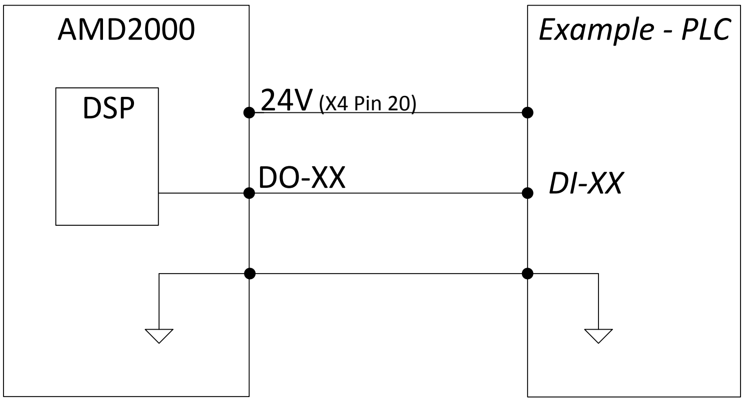
- Outputs are current sinking
- Refer to Section *12.3 Interface Specifications* for maximum current ratings
- All Digital outputs are pulled to ground

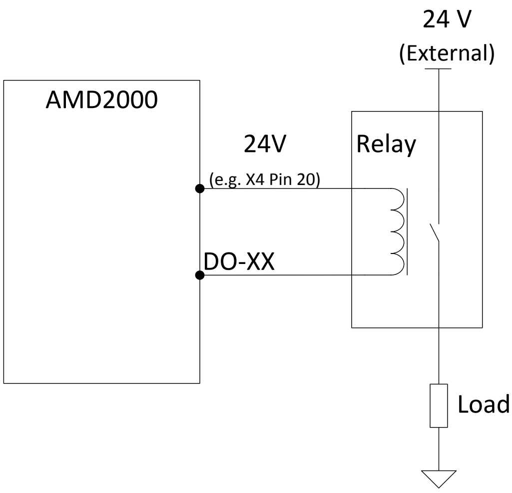
7.3.12.3.1 Idealized Drawing of Digital Output Circuit



If the output is used to drive an inductive load, such as a relay, a suitably rated fly back diode is required

7.3.12.3.2 Typical Connection Examples





7.4 Motor Brake Control

A motor brake can be connected to any of the digital outputs as previously described. The maximum current allowable is 500mA sink between all 6 digital outputs. Failure to observe this rating will result in damage to the drive.

See section *7.4 Motor Brake Control* for connection details.

7.5 Serial Communication Port

The Serial Communication Port is not enabled in this Catalogue Number.

7.6 Ethernet Interface

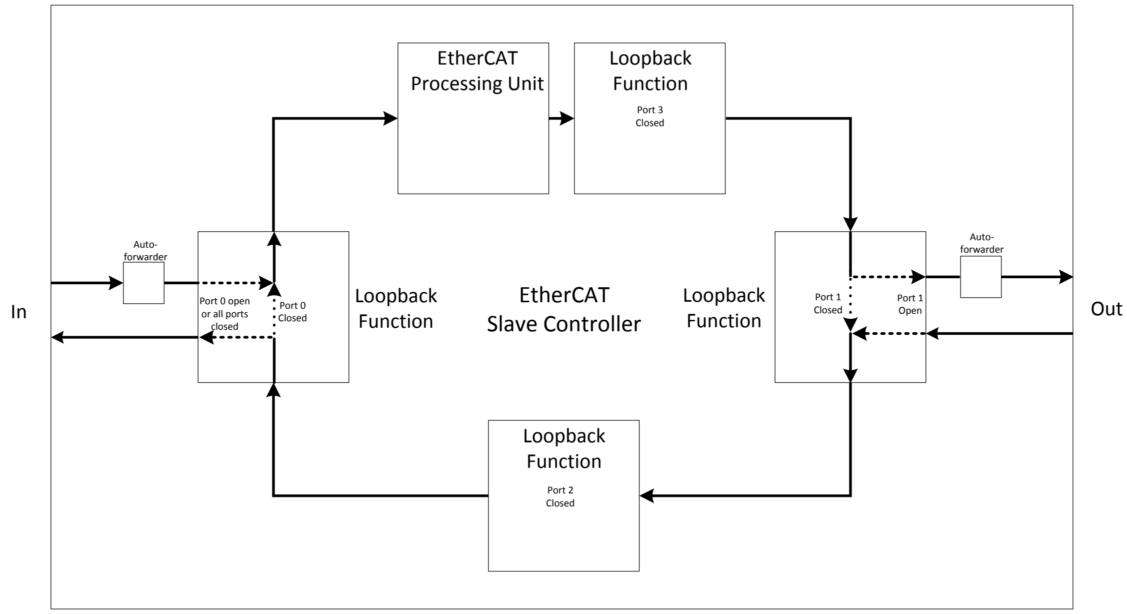
7.6.11 EtherCAT®[2]

AMD2000 supports the EtherCAT protocol with ‘Servo Profile over EtherCAT’ (SoE) capability based on the IEC61800-7 standard. This protocol provides deterministic communication over a standard 100Mbit/s (100Base-TX) Fast Ethernet (IEEE802.3) connection. This makes it suitable for the transmission of control and feedback signals between the AMD2000 and other EtherCAT enabled controllers.

[2] EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

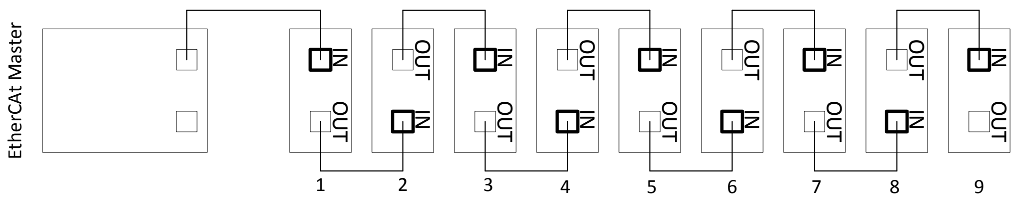
AMD2000 functions as an EtherCAT slave controller, providing two ports (IN/OUT) for connection to other EtherCAT compliant equipment. This allows nodes to be connected in many configurations such as a ring, star, or tree, with EtherCAT's self-terminating technology automatically detecting breaks or an intended end of line. If only one port is used for EtherCAT operation, it must be the X1 (IN) port.

7.6.12 EtherCAT topology / Port assignment

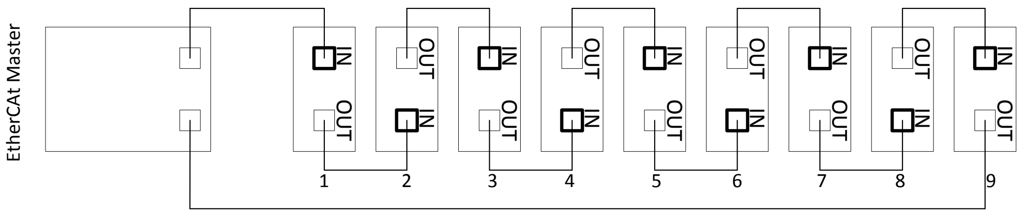


7.6.12.1 Possible EtherCAT Configurations are

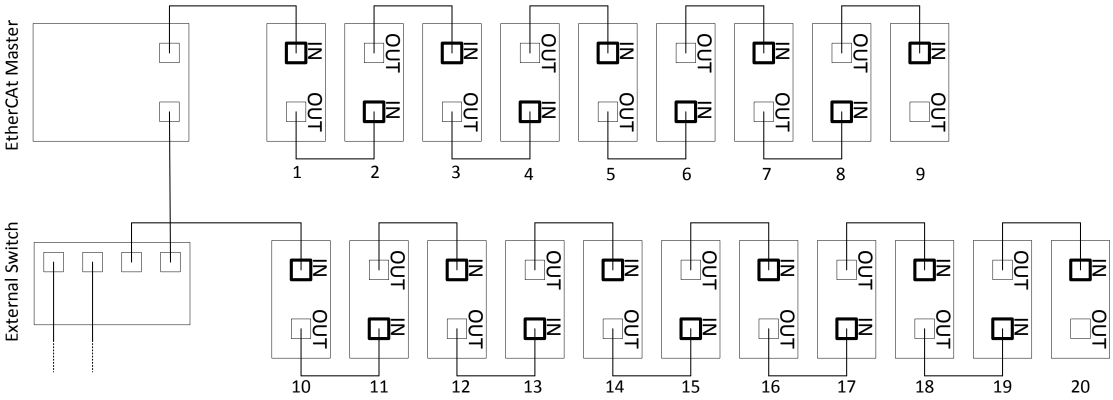
Straight Line Topology EtherCAT Network:



Ring Topology EtherCAT network:



Multi-Branch EtherCAT network:

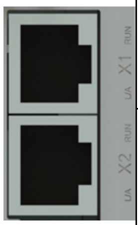


7.6.12.2 EtherCAT Configuration

EtherCAT configuration is usually performed using EtherCAT manager software. To assist with configuration, an EtherCAT Slave Information (ESI) file is provided for the AMD2000. This .xml file describes the drive's capabilities to the EtherCAT manager.

7.6.12.3 EtherCAT Connectors

X1/X2 EtherCAT IN/OUT connectors.

	X1	EtherCAT IN
	X2	EtherCAT OUT

7.6.12.4 EtherCAT Cables

To connect the AMD2000 drive to other EtherCAT devices the following types of cables must be used with 8P8C modular connectors. They are commonly referred to as "RJ45 shielded patch leads".

Cable	Name	Cable Screening	Pair Shielding
Cat 5e or Above	F/UTP	Foil	None
	SF/UTP	Foil, Braiding	None

- TP = twisted pair
- U = unshielded
- F = foil shielding
- S = braided shielding

Either straight or crossover cables may be used.
Recommended cables are listed in the accessories section *13.4.12 EtherCAT Cables*

7.7 DIP Buttons

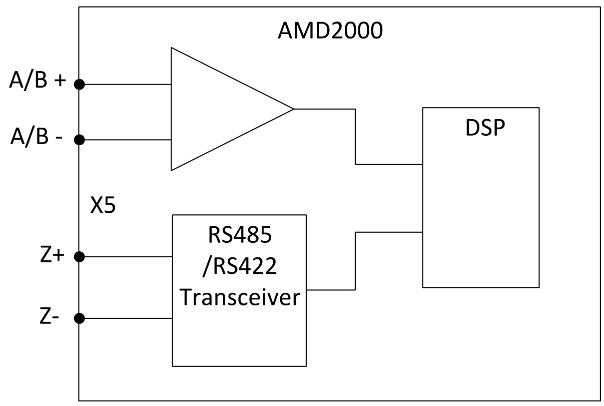
Button	Label	Function
SW4	MODE	Holding during power up will force the device into bootstrap mode
SW3	UP	Reserved
SW2	DOWN	Reserved
SW1	SET	Holding during power up will force the device into bootstrap mode

7.8 Motor Feedback

Connector	Pin Number	Label	Sin/Cos	Digital Incremental Encoder
X5	1	Sin - / A-	Sin-	-
	2	Sin + / A+	Sin+	-
	3	Cos - / B-	Cos-	-
	4	Cos + / B+	Cos+	-
	5	Ref - / Z-	Z-	-
	6	Ref + / Z+	Z+	-
	7	A+	-	A+
	8	A-	-	A-
	9	B+	-	B+
	10	B-	-	B-
	11	Z+	-	Z+
	12	Z-	-	Z-
	13	9VDC	-	-
	14	5VDC	5VDC	5VDC
	15	GND	GND	GND

7.8.11 Analog Encoder Interface

7.8.11.1 Idealized Drawing of the Analog Encoder Circuit



7.8.12 Analog Encoder Cable

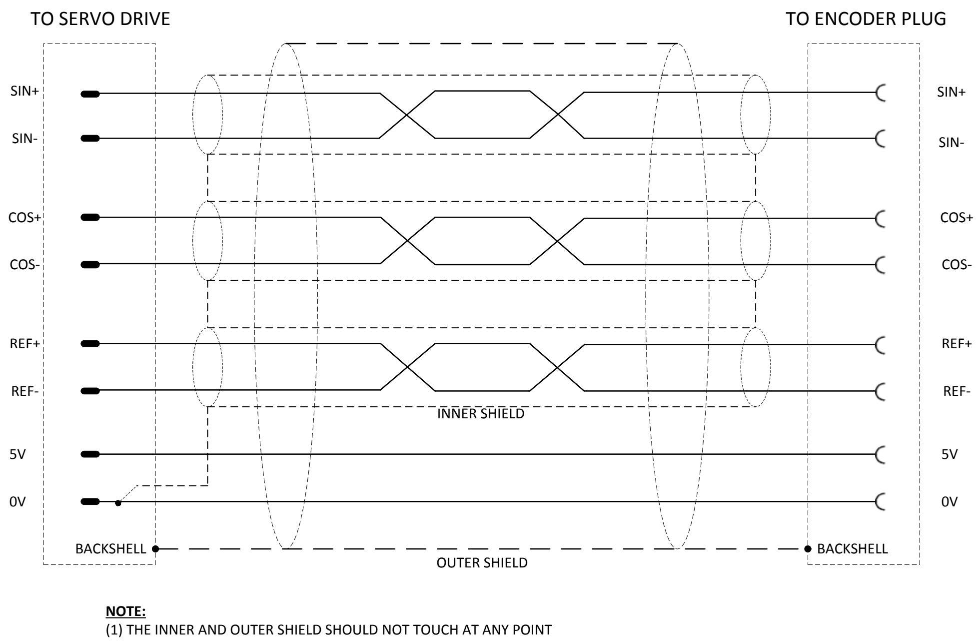
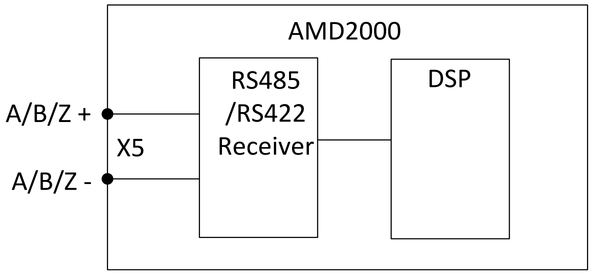


Figure 7-6 Typical Wiring Example of Analogue Incremental Encoder Wiring

7.8.13 Digital Encoder Interface

7.8.13.1 Idealized Drawing of the Digital Encoder Circuit



7.8.14 Digital Encoder Cable

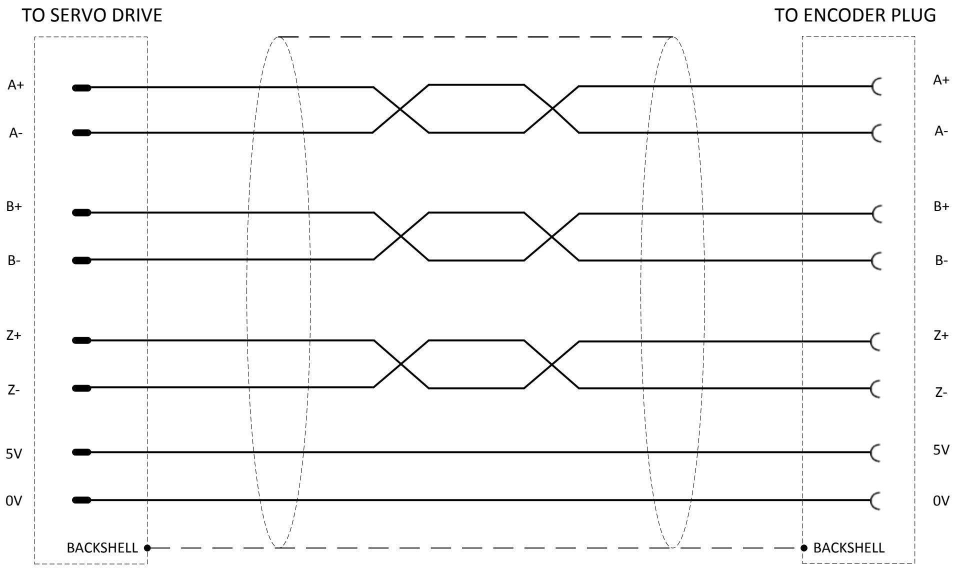


Figure 7-7 Typical Wiring Example of Digital Incremental Encoder Wiring

Recommended cables are listed in the accessories section *13.3.12 Encoder Cables*

8. Installation Checklist

8.1 What this Chapter Contains

This chapter contains a pre power up checklist aimed at ensuring safe and successful initial power up of the drive.

8.2 Checklist

	The installation location satisfies the requirements in *12.6.13 Installation and Operation*
	An adequately sized protective earth connector is installed between the drive and the installation Earth Bar
	The required ventilation clearances around the drive have been observed per section *4 Mechanical Installation*
	An adequately sized protective earth connector is installed between the drive and the motor.
	Each protective earth conductor is connected to the appropriate terminal and is secured.
	The supply voltage is within the limits of operation of the drive.
	The input power cable is connected to the appropriate terminals and the conductors are secured.
	Appropriate supply fuses and disconnect devices have been installed.
	The motor cable is connected to the appropriate terminals, the phase order is correct and the conductors are secured.
	The brake resistor cable (if applicable) has been connected to the appropriate terminals and the connections secure
	The motor cable and brake resistor cable (if applicable) have been routed away from other cables
	No power factor compensation capacitors have been connected to the motor cable
	A sinusoidal filter has been installed in between the motor armature output on the drive and the motor if required by the application
	All low voltage control cables have been correctly connected and are secure
	There is no dust or other foreign object inside the drive after installation (E.g. Due to cutting of cables etc.)
	All wiring conforms to applicable regulations and standards
	No physical damage is present to any component within the system
	The motor and all equipment connected to the drive is ready for start-up
	A risk assessment has been completed on entire machine and is considered by the user to be safe enough for operation

	Regeneration energy and power has been assessed and external resistor has been connected if required
	There are no shorts between encoder power supplies and encoder GND
	Possible load for all digital outputs does not exceed 300mA combined current sinking
	Input voltage does not exceed 265V rms between L1, L2 and L3

9. Start-up

9.1 What this Chapter Contains

This chapter contains information related to the ANCA MotionBench that will guide the user in setting up and configuring the AMD2000 Series Servo Drive:

- ANCA MotionBench Software and Installation and requirements
- Starting the drive using ANCA MotionBench
- Configuring and Commissioning of the drive
- Additional information on the ANCA MotionBench

9.2 Introduction

ANCA MotionBench is an application for inspecting and commissioning AMD2000 series drives. The MotionBench provides a connection wizard to aid in connecting directly to drive and a quick start-up wizard to get a motor moving quickly. Further panels are provided that give a functional overview and guided access to key drive functions, as well as an interface to access the entire list of parameters. MotionBench includes powerful real-time signal logging and graphing capability.

9.3 PC minimum specifications

The minimum PC requirements for MotionBench are:

- 1GB Memory (minimum)
- 2GB Free Disk Space (minimum)
- 1024 x 768 Screen Resolution 32-bit colour (recommended)
- Mouse or similar pointing device
- Microsoft .Net Framework 4
- Supported Operating System
- Supported Wired Network Adapter that is currently unused

Supported Operating Systems for MotionBench are:

- Windows XP
- Windows Vista
- Windows 7

Both 32 and 64-bit versions of Windows are supported. However, only EN-AU and EN-US are guaranteed to work. Windows for other languages are known to cause problems with MotionBench.

Supported Wired Network Adapters for MotionBench are:

- Intel 82577LM Gigabit
- Broadcom NetXtream 57xx Gigabit
- Broadcom 57765-B0 PCI
- Marvell Yukon 88E8053 Gigabit
- ASIX AX88772A (USB2.0 to Ethernet dongle)
- Realtek RTL8139-810X
- Realtek PCIe GBE Family Controller
- Realtek PCIe FE Family Controller

Most other wired network adaptors should be reliable but those listed are known to work. At this stage there are no wired network adapters which are known to be unreliable.

9.4 Configuring the Network Adapter

Warning: To connect the AMD2000 to a Laptop or PC requires the alteration of the Ethernet adapter configuration. This may affect the computer's office Ethernet connection. Installing a second Ethernet adaptor which is dedicated for use with the AMD2000 will prevent this possible limitation. If you are uncomfortable about making changes to your Ethernet adapter configuration, or do not have the required user permission levels, then please consult with your IT administrator.

Note that the AMD2000 must be directly connected to the Laptop or PC, it cannot be connected via an intermediate network.

1. Windows 7: Click Start menu, then Control Panel, then Network and Sharing Center.
   Windows XP: Click Start menu, then Settings, then Control Panel, then Network Connections.
2. Windows 7: Click Local Area Connection, then click Properties.
   Windows XP: Right-click the Local Area Connection entry for the required Ethernet adapter and choose Properties.
3. Windows 7: Select the Internet Protocol Version 4 (TCP/IPv4) entry and click Properties.
   Windows XP: Select Internet Protocol Version (TCP/IP) and click Properties.
4. On the General tab, make a note of the existing settings. Click Advanced, and make a note of any existing settings. Click Cancel and then click the Alternate Configuration tab (if one exists) and make a note of any existing settings.
5. On the General tab, choose the "Use the following IP" address option.
6. In the IP address box, enter the following IP address: 192.168.100.1. This is the IP address that will be assigned to the Ethernet adapter.
7. In the Subnet mask box, enter 255.255.255.0, no DNS settings required and Gateway IP address should be cleared and click OK.
8. Click Close to close the Local Connection Properties dialogue.

9.5 Connecting the AMD2000 to a PC

Connect the supplied Ethernet cable between the PC network port and X1 of the AMD2000 (see *3.6 Connector Overview*).

9.6 Starting the AMD2000

9.6.11 Preliminary Checks

Prior to start-up, it must be ensured that all requirements in Chapter *8 Installation Checklist* have been met.

9.6.12 Power-On Checks

DANGER - The working DC bus is live at all times when power is on. The Main Isolator feeding the drive must be switched to the **off** position at least 15 minutes before any work is commenced on the unit. The operator must check the bus voltage with a tested working voltage measuring instrument prior to disconnecting any connectors or opening the DC Bus terminal cover. The red LED indicator on the front of the drive which indicates that there is charge remaining in the drive is only to be used as an aid to visual troubleshooting. It shall not be relied on as a means of safety.

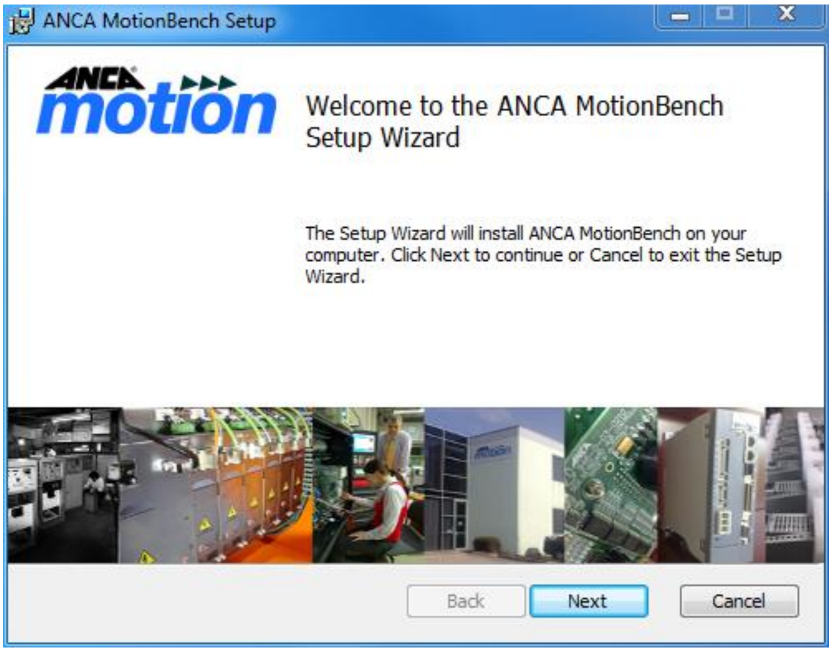
The following procedure must be adhered to during start up to ensure safe operation and functionality:

1. Ensure there are no short circuits between any two armature connections at the drive connector.
2. Ensure the drive is earthed as described in this manual.
3. Plug in all connectors.
4. The motor and all equipment connected to the drive is ready for start-up
5. Start-up of the drive will not result in any hazards in the current machine state of loading and accessibility
6. Ambient temperature is within stated manual conditions
7. Line voltages are within stated manual conditions
8. There are no shorts to encoder power supply or across armature connections
9. A machine risk assessment has been performed and the machine has been assessed as safe to use
10. The motor has an appropriate voltage and power rating matched with the drive installation conditions
11. Ensure input voltages of analog and digital inputs are within the specifications of the drive
12. Ensure the digital outputs do not sink in excess of 300mA total of all 6 outputs
13. Ensure the voltage on the digital outputs do not exceed specification
14. Ensure the encoders do not drain more current than specified encoder power supply current, and can accept the voltage tolerance of the provided output
15. Ensure the 24V output is not overloaded
16. Ensure all connectors have neat, reliable wiring (no splayed or loose copper strands, strain relief) with no shorts

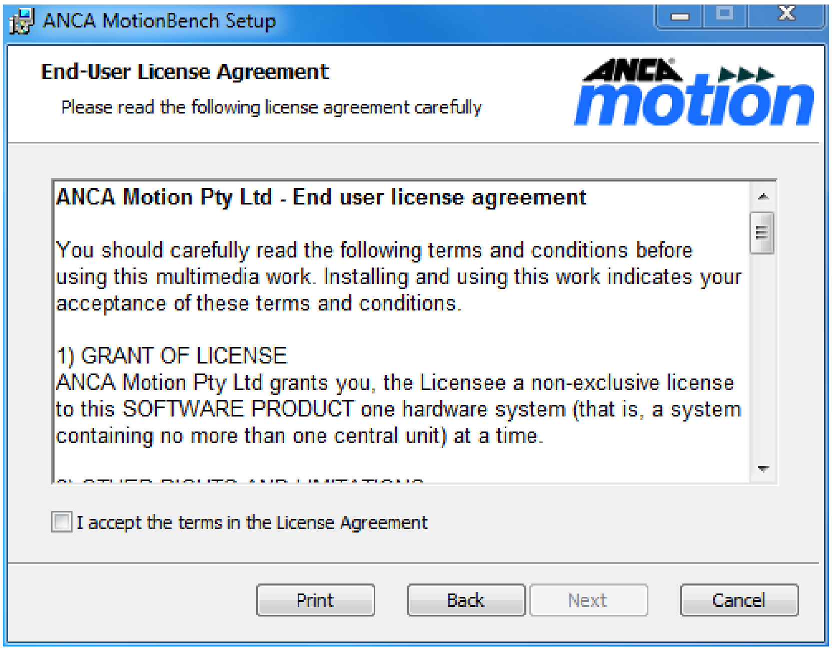
9.7 Installing the ANCA MotionBench

This section will guide you through the process to install ANCA MotionBench on your PC.

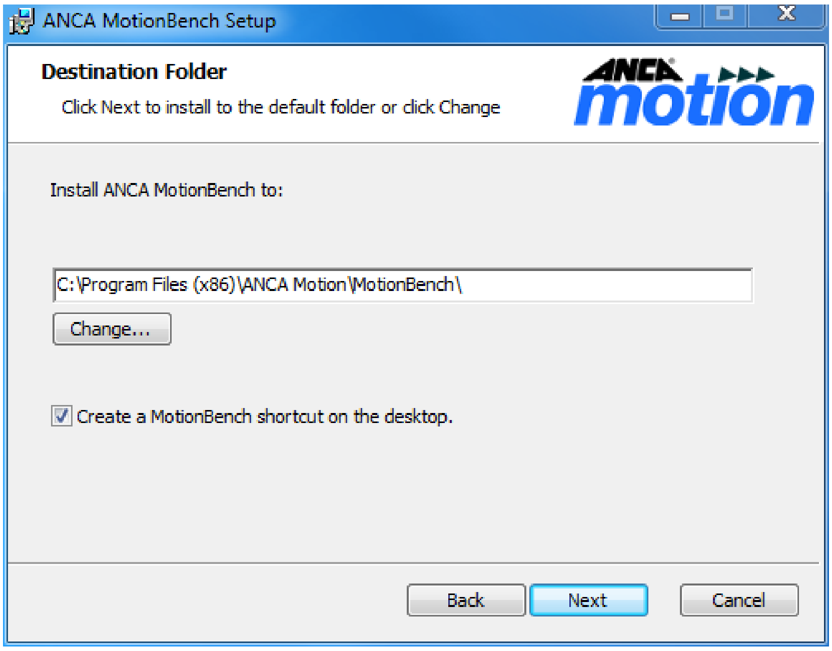
1. Ensure the previous sections in Chapter 9 have been completed.
2. Double-click on the ANCA MotionBench msi file. Latest .msi file can be downloaded from the ANCA Motion website, under Product → AMD2000 → Resources.
3. You will then be presented with the welcome screen shown below:



4. Click Next. You will then be presented with the *End-User License Agreement* shown below:

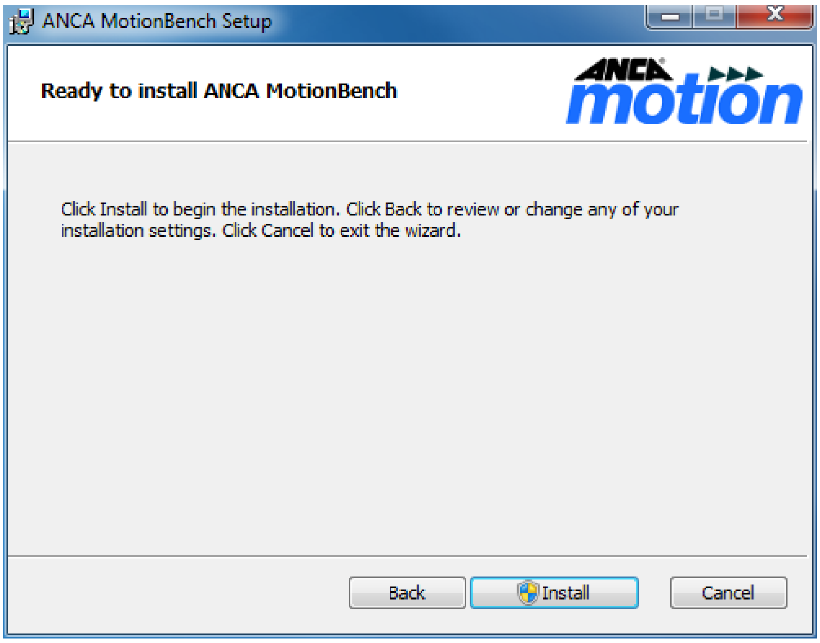


5. Please read the License Agreement and tick the “I accept the terms in the License Agreement” check box. Click Next. You will then be presented with the *Destination Folder* dialogue shown below:

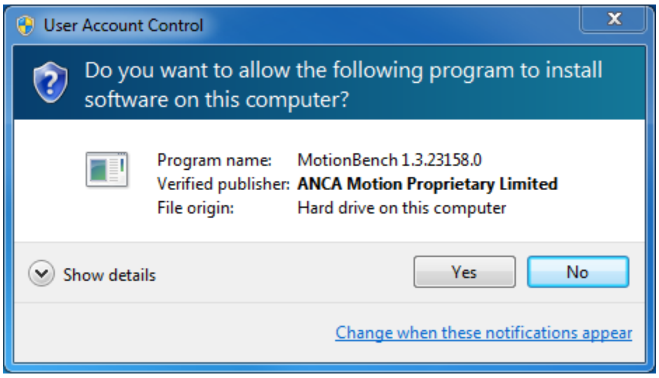


6. If you are happy with the default destination folder, simply click Next. Alternatively use the Change button to navigate to an alternative location. By default, a shortcut icon for launching MotionBench will be added to the Desktop. If you do not wish for an icon to be added to the desktop untick the “Create a MotionBench shortcut on the desktop” check box. Click Next. You will then be presented with *Install MotionBench* dialogue sown below:

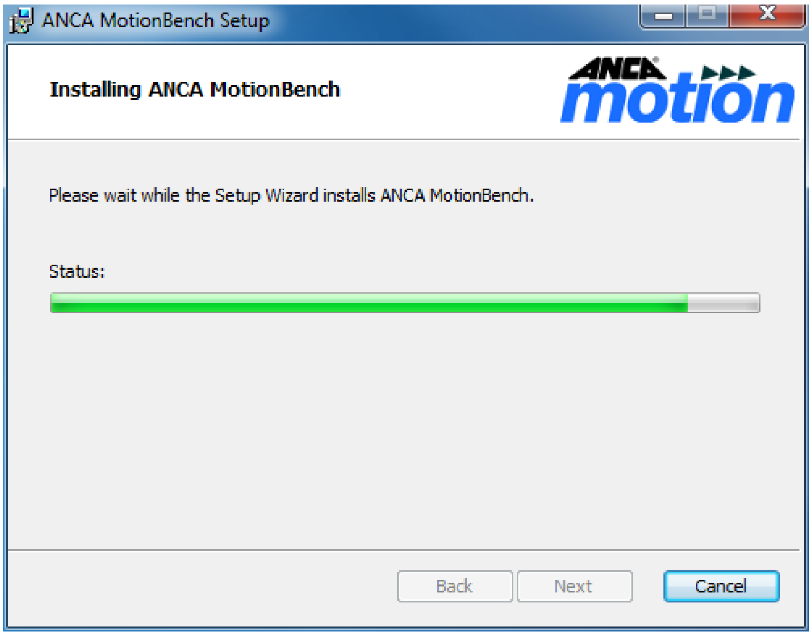
7.



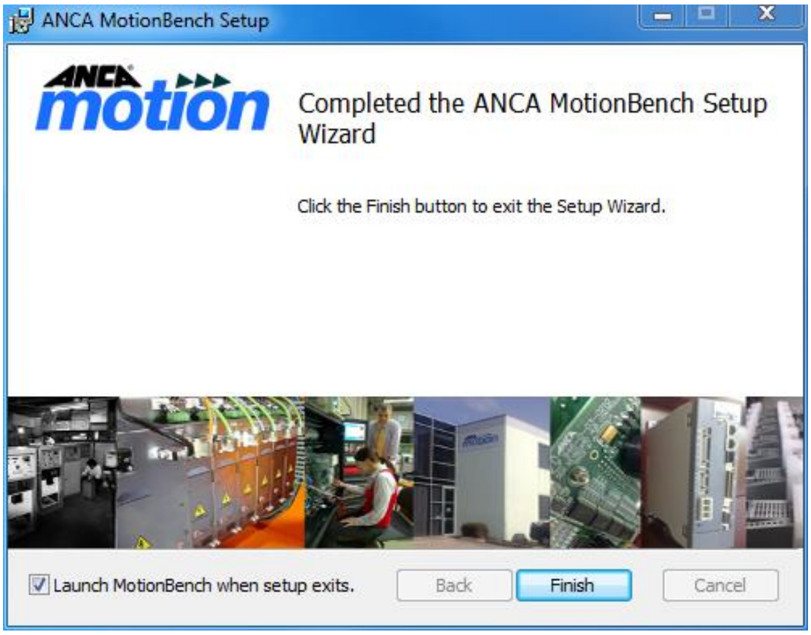
8. Click Install. You may be presented with the following dialogue:



9. Click Yes. MotionBench will then start installing on your PC. The dialogue shown below you indicate the status of the installation process.



10. When the installation process has completed the following dialogue will be shown.

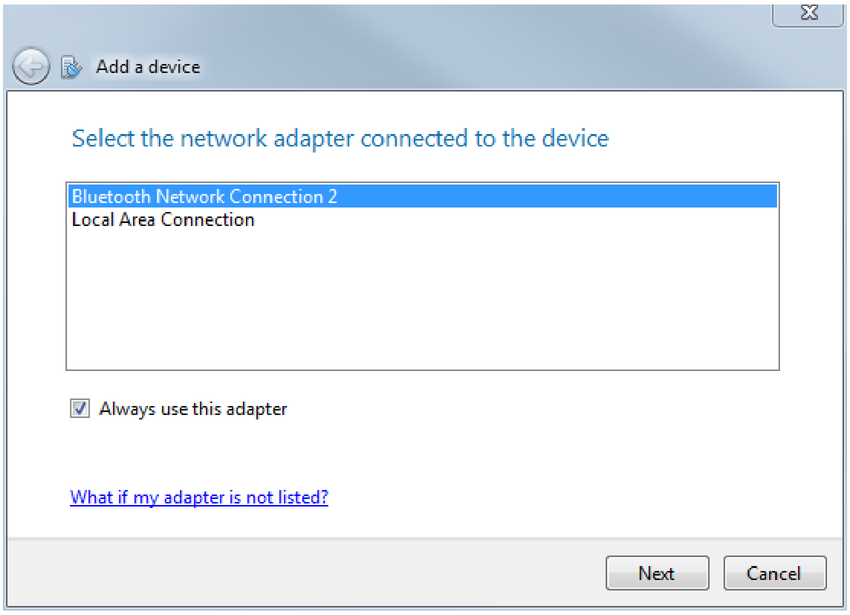


11. By default the MotionBench application will launch immediately after you click the Finish button. If you do not wish for the application to launch immediately, untick the “Launch MotionBench when setup exits” check box. Click Finish.

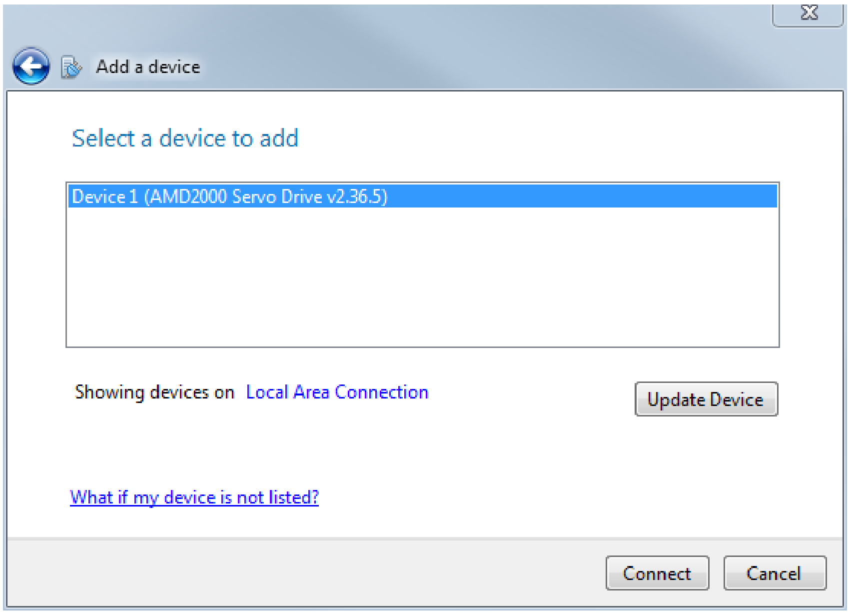
9.8 Configuring the AMD2000 Series Servo Drive

9.8.11 ANCA MotionBench

1. Ensure the previous sections in *9 Start-up* have been completed.
2. Ensure the drive is powered-on.
3. Launch Motion Bench via the start menu or desktop icon.
4. You will be presented with the *Add a device* wizard.



   a. Select the network adaptor connected to the device. This is the adapter that was configured in *9.4 Configuring the Network Adapter.*
   b. The check box "Always use this adapter" will ensure that this adapter is used for future ANCA MotionBench session (recommended).
   c. Select Next



   d. Select a device to add.

e. If the device is not listed, there are a few possible things to check:

   I. Incorrect network adaptor selected in the previous dialogue. Use the back button to confirm this setting.

   II. AMD2000 is not powered on. Power-on the AMD2000. Refer to section *9.6 Starting the AMD2000* for details.

   III. Ethernet cable between the AMD2000 and the PC is not connected. Refer to section *9.5 Connecting the AMD2000 to a PC* for details.

   IV. Network adaptor configuration is incorrect. Refer to Section *9.4 Configuring the Network Adapter* for details.

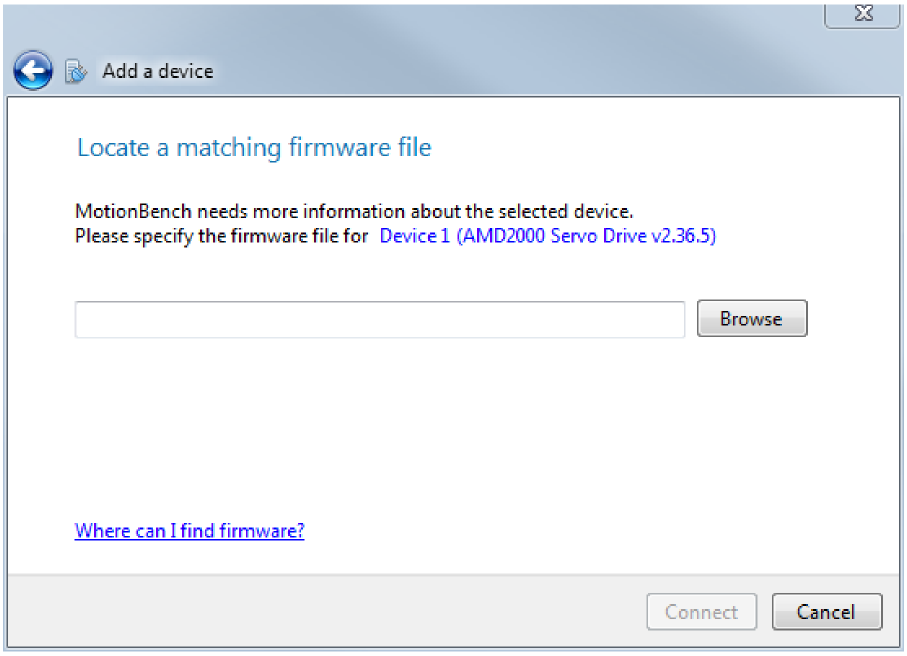
   V. Try closing the MotionBench application and then restarting.

   VI. Try power cycling the AMD2000.

   VII. Try rebooting the PC.

f. The version of the firmware currently installed on the drive is indicated. If required, this can be updated using the Update Device button. Refer to point 7 below for details.

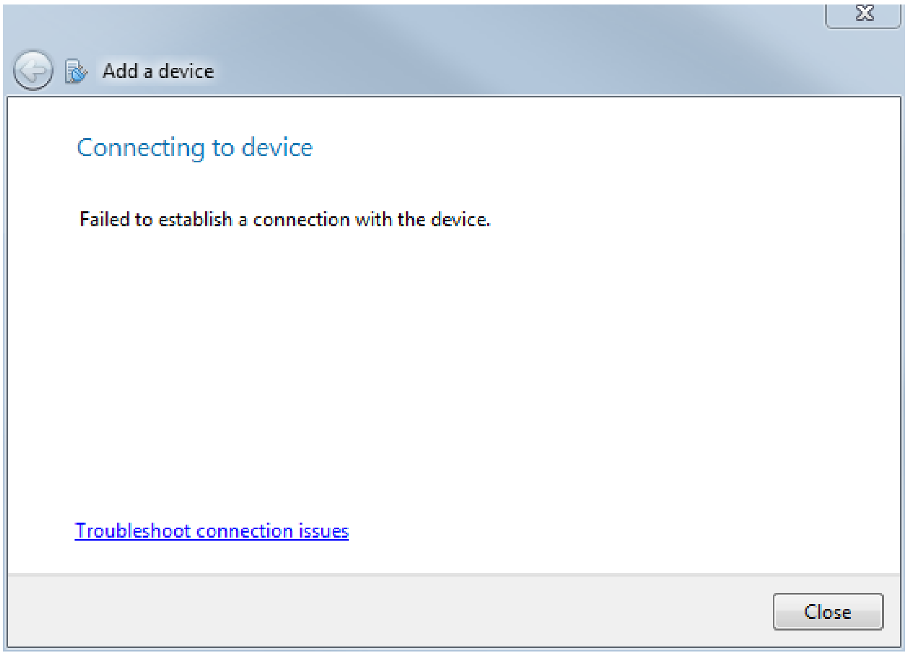
g. If MotionBench cannot locate the .amf file which matches the firmware currently installed on the AMD2000 the following screen is presented. Browse to the amf file.



h. Firmware can be downloaded from the ANCA Motion website, under Product → AMD2000 → Resources.

i. Select Connect.

j. If MotionBench fails to connect the following screen will be shown.



k. If the device does not connect, there are a few possible things to check:

   I. AMD2000 is not powered on. Power-on the AMD2000. Refer to Section *9.6 Starting the AMD2000* for details.

   II. Ethernet cable between the AMD2000 and the PC is not connected. Refer to Section *9.5 Connecting the AMD2000 to a PC* for details.

   III. Network adaptor configuration is incorrect. Refer to Section *9.4 Configuring the Network Adapter* for details.

   IV. Try closing the MotionBench application and then restarting.

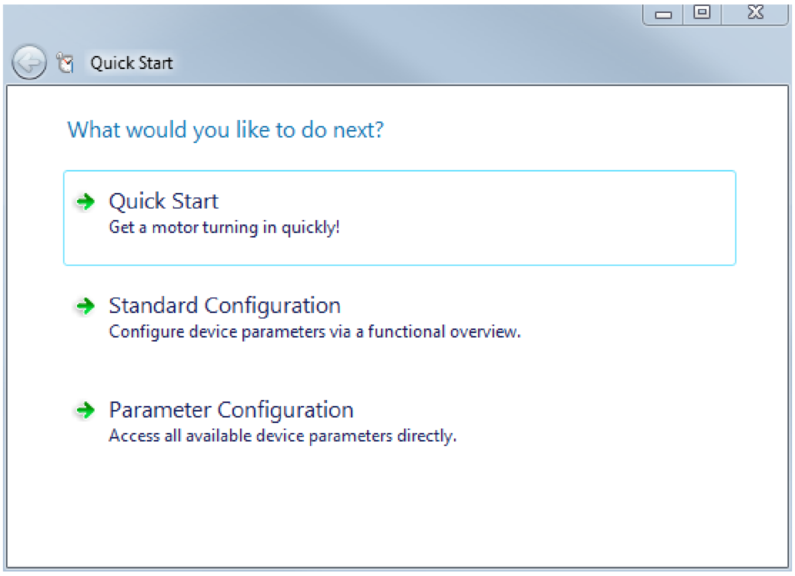
   V. Try power cycling the AMD2000.

   VI. Try rebooting the PC.

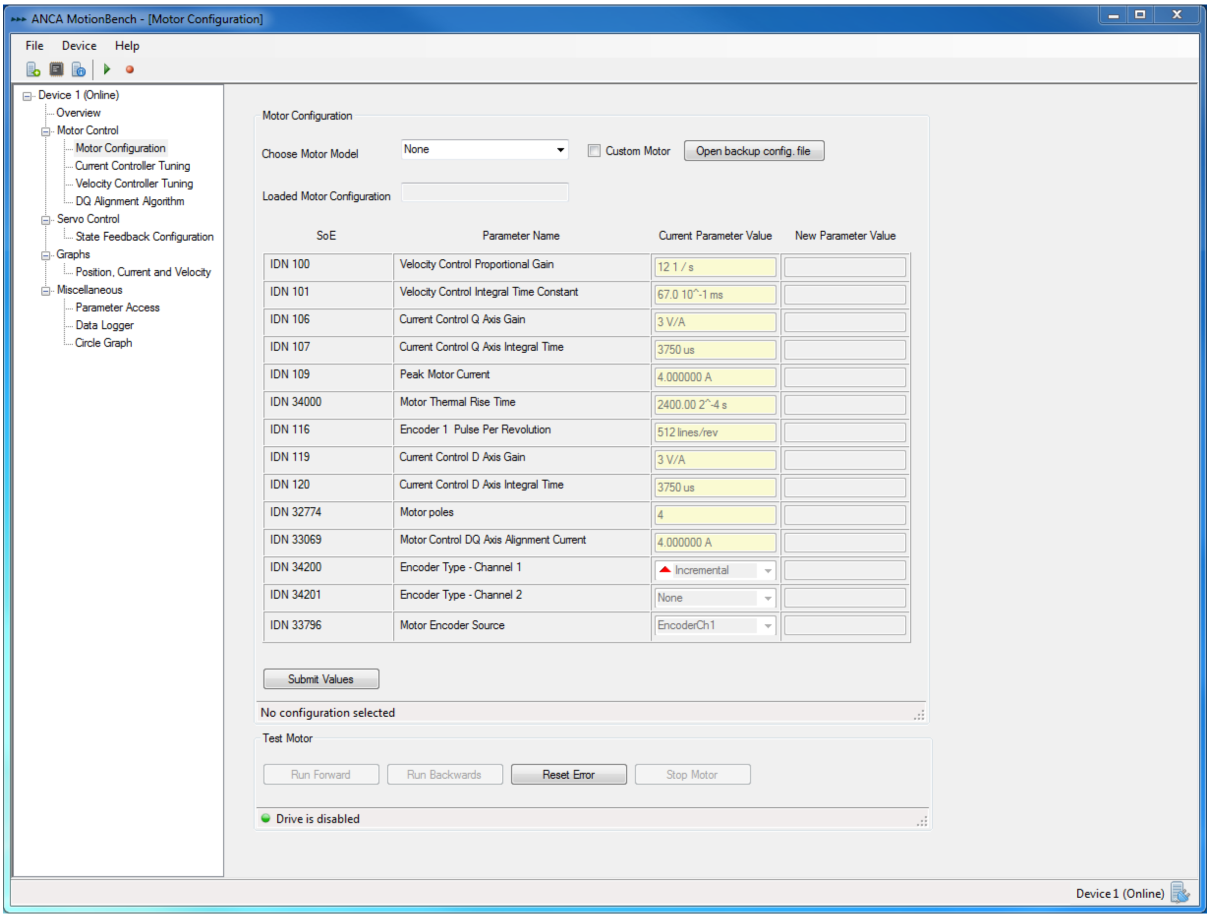
l. If MotionBench successfully connects to the drive, the Quick Start wizard will launch

5. Quick Start wizard

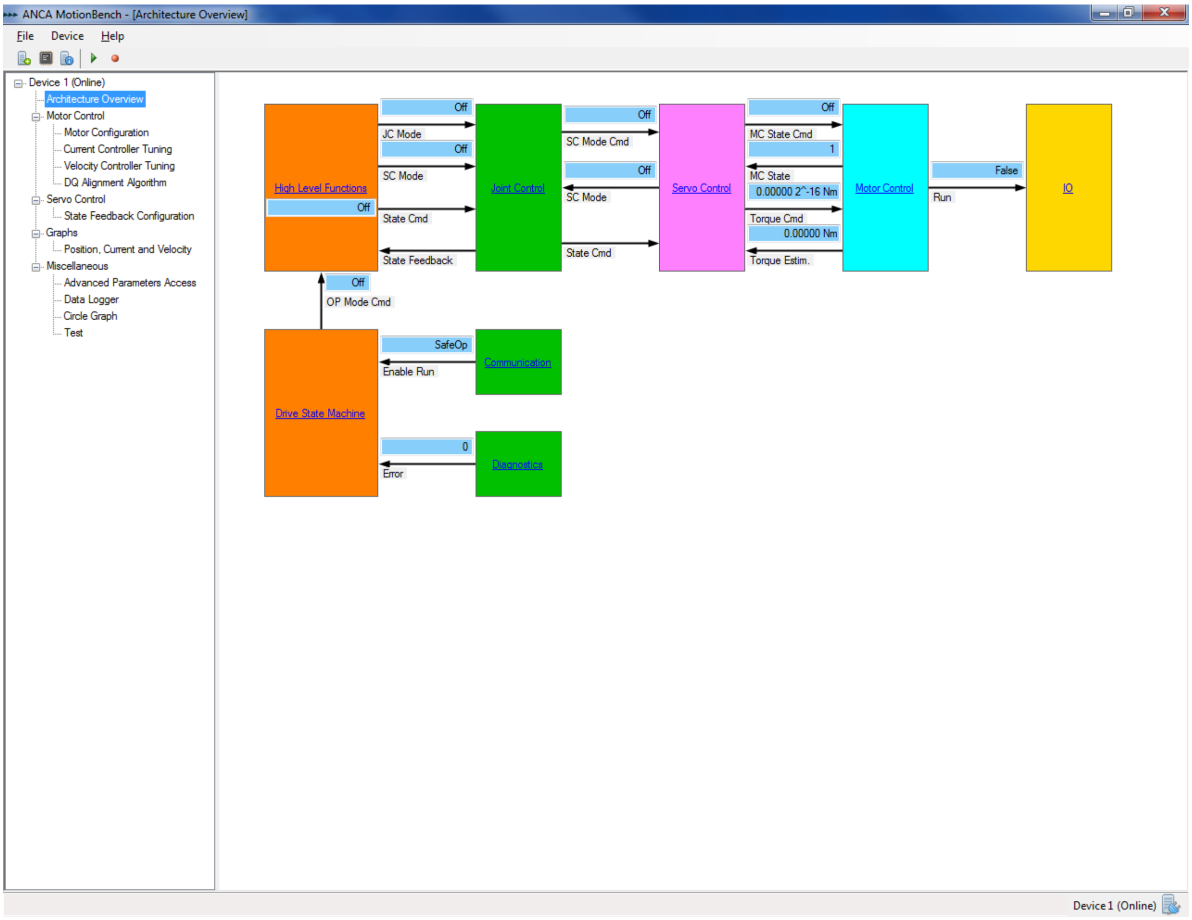
    a. When the Quick Start wizard starts you will be given three options: Quick Start, Standard Configuration, and Advanced Parameter Configuration



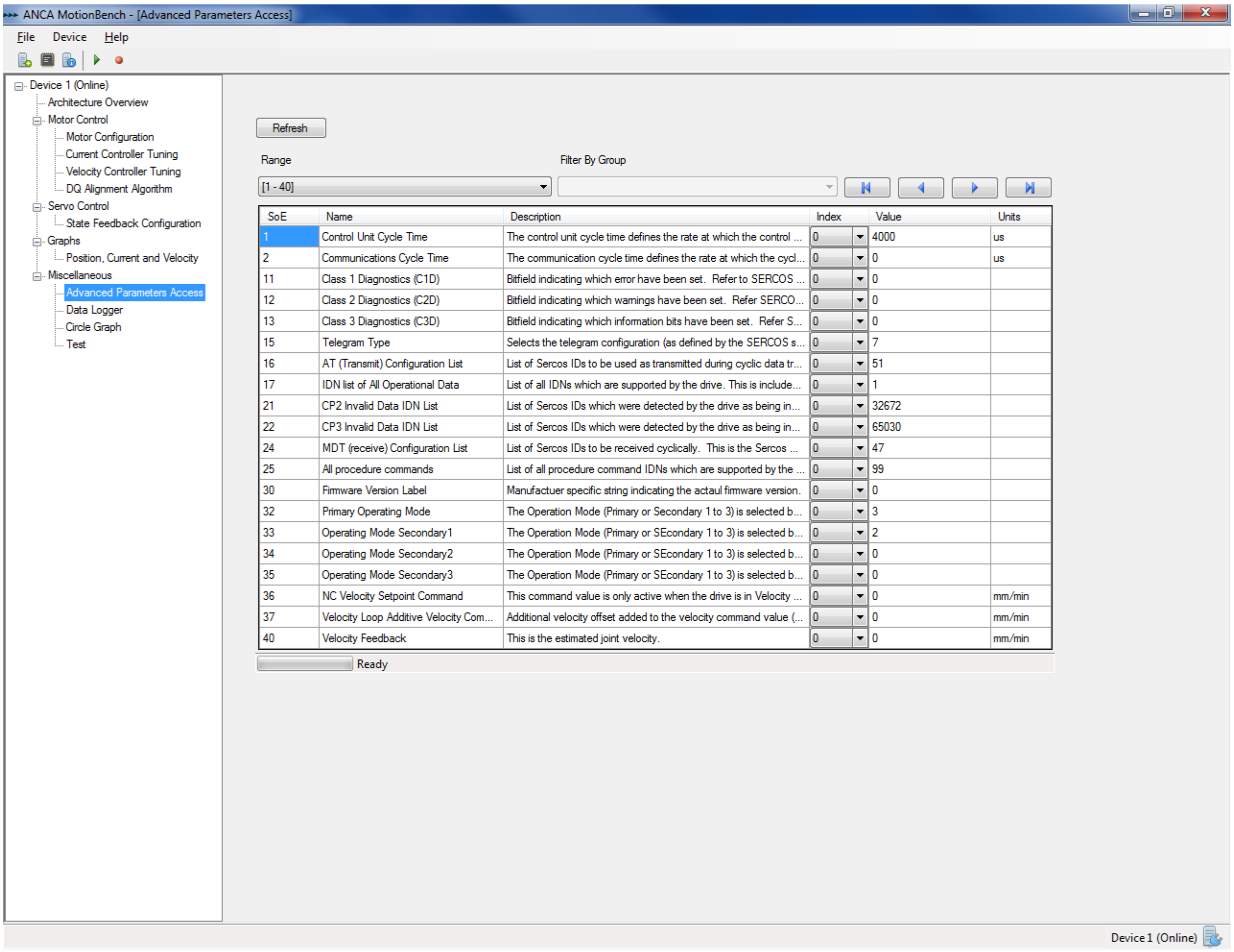
b. Quick Start will allow you to select a standard motor from the ANCA Motion range and get the motor turning with minimum effort.



c. Standard Configuration will take you to the functional overview of the drive, where you can drill down into specific function modules.

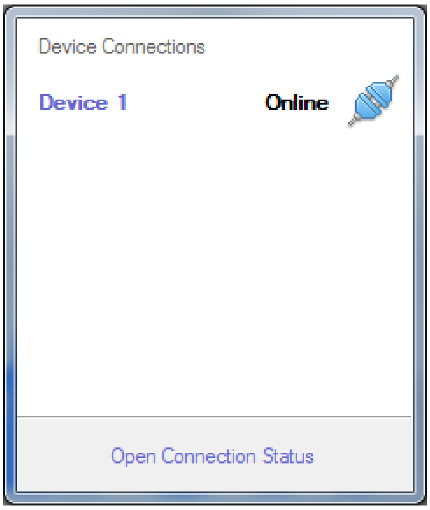


d. Advanced Parameter Configuration will take you to a table where all variables in the drive profile can be accessed.

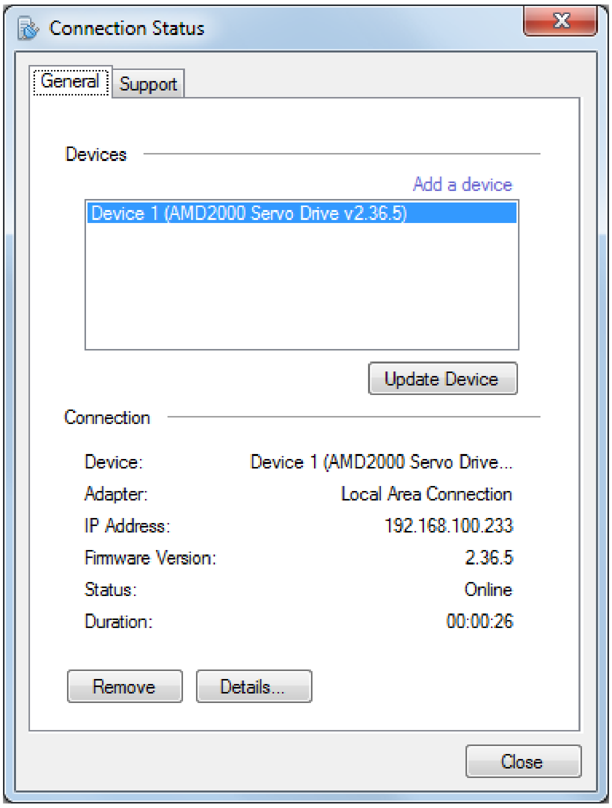


6. Connection Status Window

   a. Clicking on the Device icon in the Status Bar of MotionBench will open the dialogue shown below. This interface shows the status of the devices connected to MotionBench.



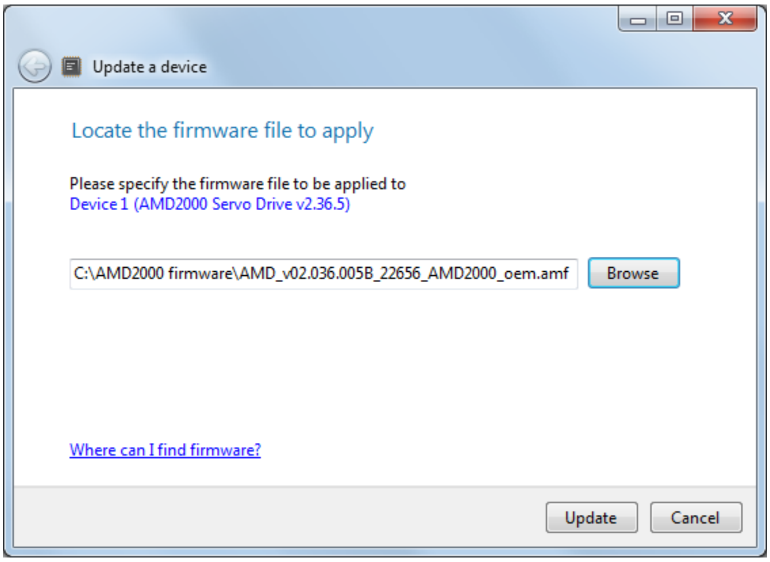
   b. Clicking on Open Connection Status will open the dialogue shown below. Here addition information regarding the status of the device can be viewed. As well, it provides an interface to update the device firmware via the Update Device button. See point 7 for details.



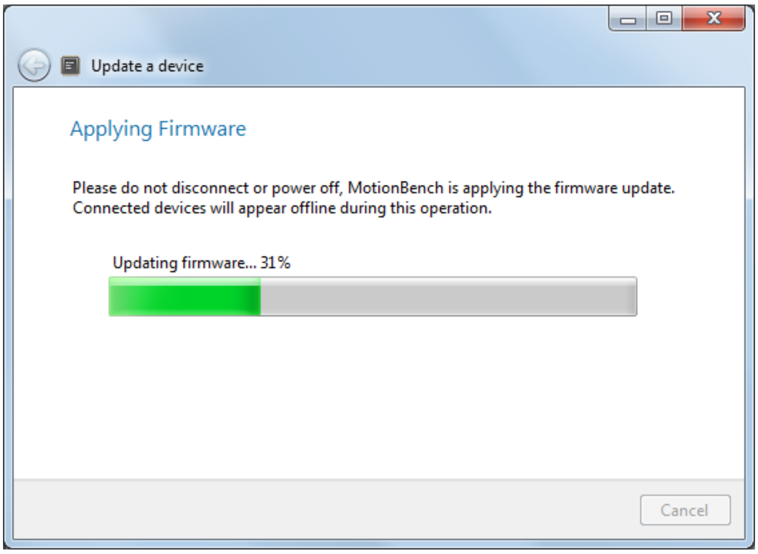
7. Update Device Firmware wizard

   a. Select Update Device button as part of the Add a device wizard (see point 4), or from the Connection Status window. (see point 6).

   b. The Update a device dialogue shown below will open.

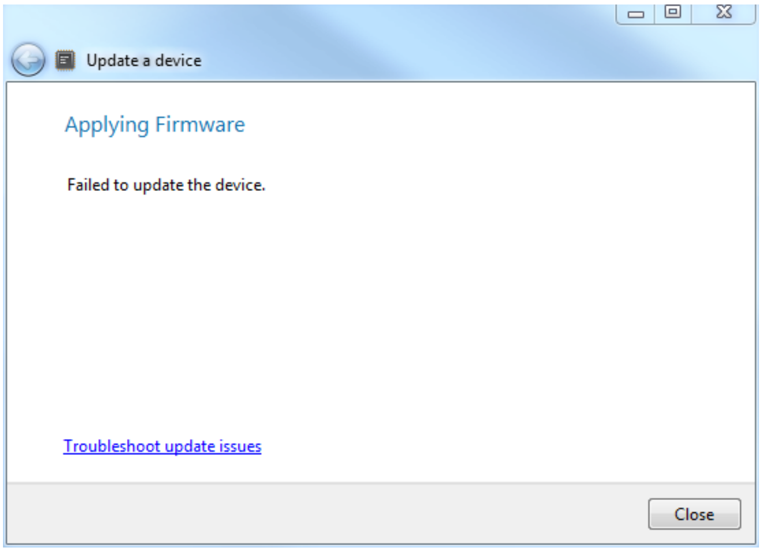


   c. Browse to the amf file. Note that the Update button will only become available if a valid firmware file is selected. Click Update.



   d. Firmware can be downloaded from the ANCA Motion website, under Product → AMD2000 → Resources.

   e. If MotionBench fails to update the firmware on the AMD2000, then the following screen will be shown.



m. If the firmware fails to update, there are a few possible things to check:

I. AMD2000 is not powered on. Power-on the AMD2000. Refer to Section 9.6 for details.

II. Ethernet cable between the AMD2000 and the PC is not connected. Refer to Section 9.5 for details.

III. Network adaptor configuration is incorrect. Refer to Section 9.4 for details.

IV. Try closing the MotionBench application and then restarting.

V. Try power cycling the AMD2000.

VI. Try rebooting the PC.

10. Feature Configuration

10.1 What this Chapter Contains

The following sections illustrate the use of the AMD2000 series drives in standalone mode for configuration or execution of a variety of common tasks.

10.1.11 Analogue Encoder Compensation

Description

Analogue encoder compensation provides the user with the ability to adjust the raw SINCOS encoder signals from the motor in order to compensate for static zero level offsets, or linear scaling imperfections in the encoder feedback. Consider using encoder compensation when a plot of the raw SINCOS encoder feedback signals is not centred on zero, or is not a perfect circle. Such a plot can be generated using the ANCA MotionBench software supplied with the AMD2000. A detailed procedure is described below.

Software/Hardware Requirements

- AMD firmware v02.036 or above

Procedure for Testing and Setting Up Encoder Compensation

Step 1: Using the ANCA MotionBench to capture and plot SINCOS encoder signals

Make sure that the SINCOS encoder is connected (see Section *3.6 Connector Overview*), configured (see Section *10.1.18 Field Orientation Initialisation),* and your personal computer is linked to the drive (see Section *9.5 Connecting the AMD2000 to a PC*). Start-up ANCA MotionBench (see *Section 9.8 Configuring the AMD2000 Series Servo Drive*), and navigate to the Circle Graph interface. Start the measurements. If possible, rotate the motor shaft by hand, or alternatively, use the *Start Motor* button on the page. You should then see data points begin to appear on the page in an approximately circular shape.

Figure 9-1 shows a screenshot of the ANCA MotionBench when running the associated Circle Graph for a typical SINCOS encoder setup. The topmost left corner of the Circle Graph Tab shows five buttons; “Start Measurement”, “Clear”, “Motor Encoder”, “ZX”, and “ZY.”

Start Measurement must be pressed in order to start recording data and update the graph on display. Once pressed, the button will toggle to “Stop Measurement” so the user may select when to cease gathering data. The graph will automatically update while measuring.

Clear can be selected to erase the data and start again from the default settings. It is possible to clear the plot while taking measurements.

Motor Encoder is a drop down box that allows the user to choose from the available list of SINCOS encoders connected to the drive.

ZX stands for Zoom X. It allows the user to zoom in on the X axis (Encoder cosine data) by selecting a region using the mouse. The first click and hold selects the starting point while the subsequent drag and release of the mouse button selects the end point of the region to be zoomed.

ZY is similar for zooming as ZX, above, but for the Y axis.

The horizontal axis, or abscissa, represents the scale for the cosine signal from the encoder, whereas the vertical axis, or ordinate, is the sine signal scale. Units for the two axes are ADC (analogue to digital conversion), and both the maximum and minimum allowable levels of ADC are plotted as circles on the graph. The raw encoder signals should fall within these two bounds. Both the raw encoder output and the user adjusted (“Adj.”) outputs will be shown plotted on the same Circle Graph. The user determines the shape of the adjusted output by *Figure 10-1*). The user receives immediate visual confirmation of the effect of their changes by inspecting the Circle Graph “Adj.” outputs.
If the user positions the mouse cursor to ‘hover’ above each of the Adjustment Parameter titles, then a tool tip will appear displaying the IDN of the particular parameter and its title in the data dictionary (as shown in *Figure 10-1* Circle Graph Tab for IDN 33804).

If the user prefers to see all the encoder signals rendered individually in the time domain (rather than sine versus cosine), then they can choose instead to examine the Tab labelled “Time Domain” rather than the default Tab “Circle Graph.” The same operations can be performed when viewing the time domain data, and in addition the user can choose to zoom in on both horizontal and vertical data simultaneously using the ZXY button (see *Figure 10-2*).

Step 2: Measure the minimum and maximum values of the raw sin and cos signals

For convenience the following symbols are defined:[3]

- S_{min} – minimum value of raw unadjusted sin signal
- S_{max} – maximum value of raw unadjusted sin signal
- C_{min} – minimum value of raw unadjusted cos signal
- C_{max} – maximum value of raw unadjusted cos signal

It is recommended that the user select from the appropriate Zoom buttons on either Tab to obtain a high resolution plot of the region close to the appropriate minimum and maximum data that they wish to collect. They can then obtain high resolution ADC values to supply from the above measurements, for the purposes of the next step of calculation.

Step 3: Calculate the offsets and gains for correcting the sin and cos signals

Step 3.1 Calculate the gains for correcting the SINCOS signals.

$$\text{Gain}_{\text{sine}} = \frac{1}{2} + \frac{1}{2}\left(\frac{C_{\max} - C_{\min}}{S_{\max} - S_{\min}}\right) \text{ , } \text{Gain}_{\text{cosine}} = \frac{1}{2} + \frac{1}{2}\left(\frac{S_{\max} - S_{\min}}{C_{\max} - C_{\min}}\right).$$

Step 3.2 Calculate the offsets for correcting the SINCOS signals.

$$\text{Offset}_{\text{sine}} = -\frac{S_{\max} + S_{\min}}{2} \text{ , } \text{Offset}_{\text{cosine}} = -\frac{C_{\max} + C_{\min}}{2}.$$

Step 4: Visually verify the SINCOS signals have been properly compensated

Check the updated Circle Graph for whether the adjusted SINCOS signals are more closely reflecting a perfect circle than the raw unadjusted data. This can be done while taking measurements so the adjustments are seen live on axis.

[3] note: these symbols do not refer to the minimum and maximum allowable encoder values shown in the plots, but are instead the minimum and maximum values of the raw encoder outputs.

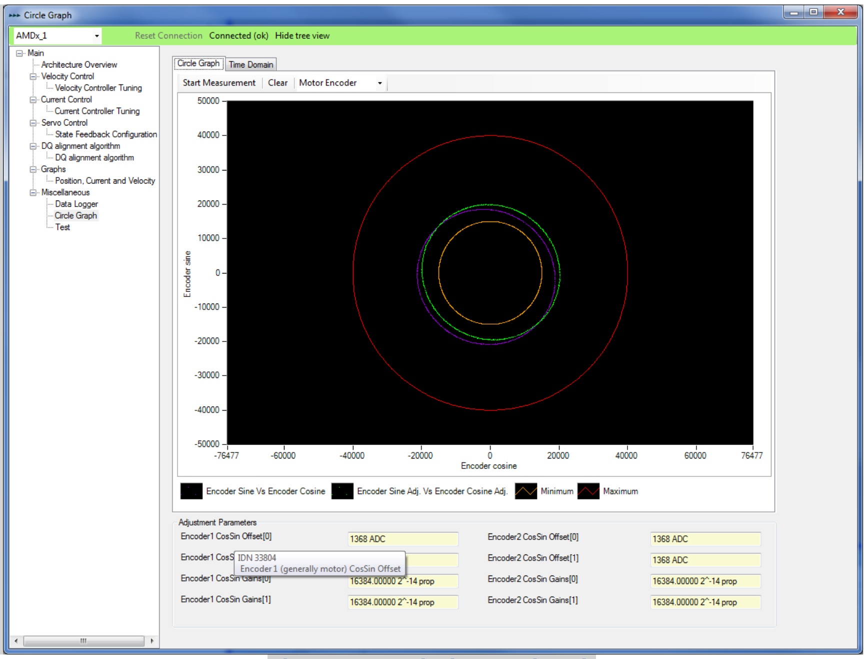


Figure 10-1 Circle Graph Tab

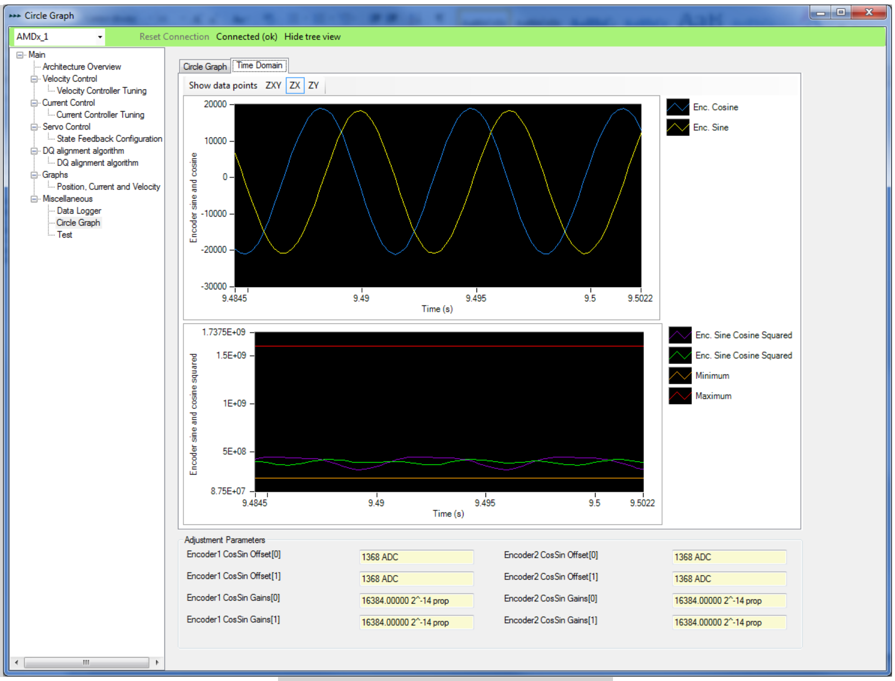


Figure 10-2 Time Domain Tab

10.1.12 Backlash Compensation

Description

The 'end effector' or 'working position' of a machine may have any number of backlash or tolerance stacks located in the drivetrain between itself and the driving torque of a motor (e.g. gaps in mating gear teeth, splines etc.). Consequently the position of the end effector is not always directly proportional to motor position. This is particularly true when the drive train is reversing direction, and consequently has to traverse this region of backlash before all components re-engage and the motor can drive the end effector in a positive fashion. High performance machines generally minimise backlash, but cannot always eliminate it, especially with wear and differential temperatures between components.
Backlash compensation allows the user to adjust the estimate internal to the drive for the end effector position, when only motor position is measured. It is generally not necessary when the end effector position is measured directly. The compensation algorithm monitors the controller's internal velocity demand to determine when a reversal in direction of motion is likely to occur. The user then has the opportunity to use three key parameters to adjust position estimation.

IDN	Description
S-0-058 / 58	Backlash Compensation Clearance
P-0-847 / 33615	Backlash Compensation Min Speed
P-0-849 / 33617	Backlash Compensation Slew Limit

Clearance is the fixed value of likely backlash by which the end effector position estimate adjusts the raw position determined from motor feedback and scaling. It is possible for this value to be either positive or negative with respect to its reference value of 0.0. See below for more details concerning the setting of clearance and homing the machine.

Min Speed sets the lowest value of speed above which compensation will be applied (it defaults to 0.0)

Slew Limit is a fractional value between 0.0 and 1.0 that determines how fast the fixed clearance value will accrue to the position estimate. For example, 0.1 indicates that for every Task 1 update of the position controller at 250 us intervals, the clearance value will increase by 10% of its final value. After 10 such intervals it will apply the full fixed Clearance value, and this value is maintained from then onwards. Setting this parameter to 1.0 will result in the immediate application of the full Clearance value at the next position estimate update. Similarly setting this to 0.0 means the Clearance value is never applied, and no adjustment to position is made.

The direction of homing is important for the successful application of this compensation technique, as it relates directly to the correct sign (+/-) of the applied clearance value and will vary depending on the particular machine setup. When the machine moves in the direction in which it was homed, effectively no clearance offset is applied, as positions generated when moving in this direction are taken as the reference for backlash. When moving in the opposite direction, however, the full clearance value will be applied after appropriate accrual due to slew limits *Figure 10-3* and *Figure 10-4* illustrate the algorithm's implementation.

Software/Hardware Requirements

- AMD firmware v02.036 or above

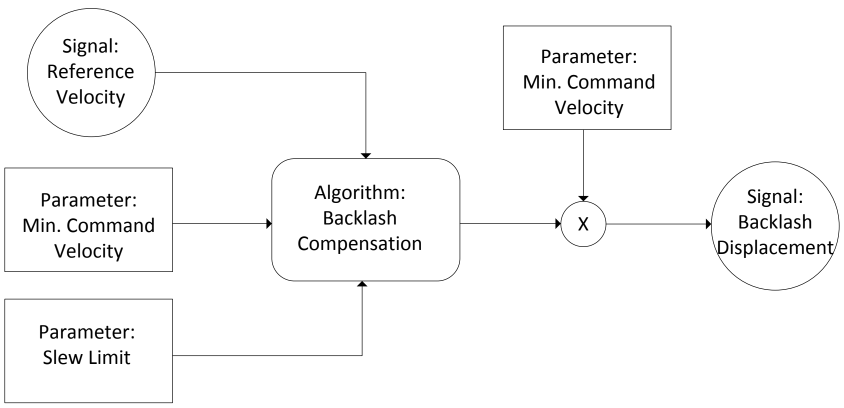


Figure 10-3 Backlash Compensation Data Flow

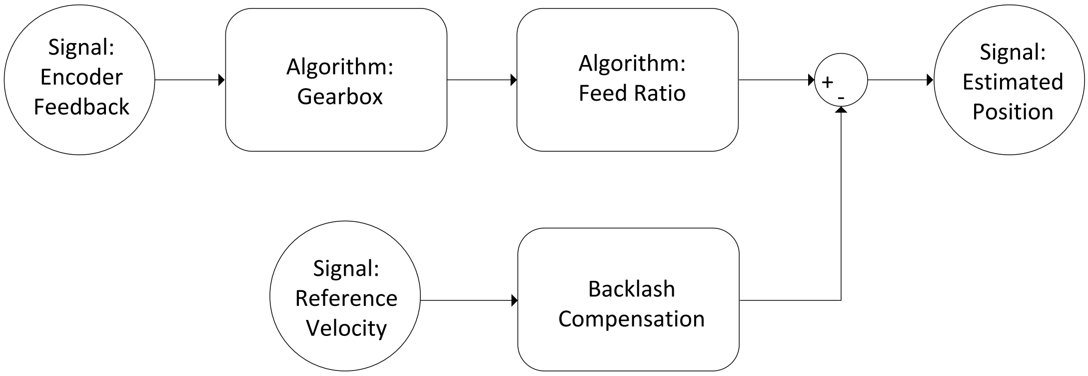


Figure 10-4 Illustrating where backlash compensation fits into the motor feedback path

Procedure for Testing and Setting Up Backlash Compensation

Make sure the motor and its associated motor encoder are setup and enabled and your personal computer is linked to the drive (see Section *9.5 Connecting the AMD2000 to a PC*). Start-up ANCA MotionBench (see Section *9.8 Configuring the AMD2000 Series Servo Drive*), then navigate to the Advanced Parameter Access interface.

In the field, it is common practice to use a dial gauge and command step moves forward and backwards and monitor the backlash compensation. The backlash compensation clearance can be adjusted by feel, as can the slew limit.

10.1.13 Configuring Wire-Saving UVW Motors

Warning: This feature is recommended to be used only on braked axes, or axes that are unable to move.

Description

This document describes how to use UVW wire-saving encoders with AMD2000 drives to perform Field Orientation Initialisation (FOI). It is important to note that the FOI alignment angle is latched during power-up. If you have downloaded code (or have entered into BOOTSTRAP mode), you MUST power cycle the drive. Note that this feature is only supported on drive encoder channel 2.

IDN	Description
P-0-006 / 32774	Number of motor poles
P-0-297 / 33065	Field Orientation Initialisation Type
P-0-312 / 33080	Absolute Feedback Type
P-0-579 / 33347	UVW Hall Sensor Source

Note on FOI and Index Pulse Offset Alignment

As UVW wire-saving estimation of the field alignment only provides an estimate of optimal angle for Field Orientation Initialisation, this method is usually combined with index pulse offset alignment to maximise the output torque and efficiency of the motor. See Section *10.1.18 Field Orientation Initialisation* for details of how to use these methods together.

Procedure for setting up a UVW wire-saving Motor

1. Set UVW Hall Sensor Source (IDN 33347) to 3 (wire-saving Encoder 2).
2. Program the correct number of motor poles (IDN 32774).
3. Set Absolute Feedback Type (IDN 33080) to 2 (UVW hall sensors).
4. Set Field Orientation Initialisation Type (IDN 33065) to 3 (Absolute).

Warning: Excessive movement (more than 30 electrical degrees) between drive power-up and when the drive firmware loads will result with an invalid field alignment, potentially resulting in axis run away. This feature is recommended to be used only on braked axes, or axes that are unable to move. If ever entering into the boot loader during drive operation, always power cycle the drive as the UVW signals will not be correct.

10.1.14 Digital Output

Description

The AMD2000 comes with 6 digital outputs (see Section 3.6). These provide a powerful and flexible means of conveying information or making requests for actions external to the drive. They are highly configurable, being able to provide useful information during normal operation, as well as under those conditions where the drive as an EtherCAT[4] device is no longer in its operating (OP) state. For example, an EtherCAT SAFEOP state might result from abnormal conditions related to loss of communication or software crashes, or the INIT and PREOP states can result from drive entering initialisation and start-up conditions.

[4] EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

The AMD2000's compliance requirements for EtherCAT marking requires the drive to ensure that the 6 digital outputs are set to a user defined safe state whenever the drive is in SAFEOP, while the drive itself simultaneously and automatically removes torque from the motor. In the AMD2000 this is achieved by requiring the digital outputs to enter their safe state settings whenever the drive leaves OP state.
The user is able to manipulate up to 7 different IDN to configure the desired setting of the digital outputs, for both OP and Non-OP states of operation. These IDN are as follows,

IDN	Description	Data Type	Scaling
P-0-0576 / 33344	Digital Output Polarity	Unsigned Integer (4 bytes) LSB corresponds to output 0 Bit = 1: Inverted	None
P-0-0577 / 33345	Digital Output Data	Unsigned Integer (4 bytes) LSB corresponds to output 0	None
P-0-0582 / 33350	Digital Output Source IDN List	Unsigned Integer Array (2 bytes) (Length = 32) Index 0 corresponds to output 0	None
P-0-0583 / 33351	Digital Output Invert Mask	Binary (2 bytes) (Length = 32) Index 0 corresponds to output 0 Array Item = 1: Inverted	None
P-0-0584 / 33352	Digital Output Source Bitmask	Binary (2 bytes) (Length = 32) Index 0 corresponds to output 0 Array Item = 1: GPDIO Active	None
P-0-0585 / 33353	Digital Output User Configurable Default Safe State – General Purpose	Binary (2 bytes) (Length = 32) Index 0 corresponds to output 0	None
P-0-0586 / 33354	Digital Output User Configurable Default Safe State – Hardware Level	Unsigned Integer (4 bytes) LSB corresponds to output 0	None

The details of the process by which the digital outputs are set is described below, and represented graphically in *Figure 10-5* . Clearly the bits in IDN 33350 are critical in determining whether the corresponding digital output is referred to as "General Purpose," or as a "Hardware Level" digital output. These variables can be accessed through the Advanced Parameter Access interface in ANCA MotionBench.

- Digital Output Polarity (33344)
  - is a 32 bit bitmask that is applied directly to 33345 in order to determine the final bit setting of the digital outputs. Essentially it can reverse the logic level output for any particular bit in 33345.
- The Digital Output Data (33345)
  - represents up to 32 bits of information, of which ONLY the first 6 least significant bits are used by the digital outputs of the AMD2000. These represent the actual digital output that is intended to be sent to the digital pins at each scan update interval of 4 ms (although faster rates can be achieved with special configuration). Bit 0 of 33345 corresponds to digital output 1, bit 1 is digital output 2, and so on and so forth. Therefore, a program or user may pass any Boolean values they wish through these digital outputs by setting the values in the appropriate bits of IDN 33345.
- Digital Output Source IDN List (33350)
  - However, IDN 33350 can override and replace any information that has been directly written to 33345. IDN 33350 is a 32 element array capable of holding up to 32 separate IDN's.
  - If an element of 33350 is non-zero, then the element's value is taken to represent an IDN that contains information to be issued to the corresponding digital output. Since the digital output can only be set for Booleans, if the value contained in the relevant IDN variable is non-zero, the intent will be to set the associated digital output via IDN 33345 to 1, and otherwise set it to 0 (note, IDN 33344 can be used to reverse this output arrangement).
  - If alternatively the element of 33350 is zero, and the drive is in normal operation (OP), then the corresponding bit in 33345 will **NOT** be overwritten, and the information that is already contained in 33345 will be relayed to its associated digital output (again, assuming no further bitmasking is being applied by IDN 33344).
- Digital Output Invert Mask (33351)

  - is a 32 bit variable that can be used to apply further logic to the bit setting originating from either 33353 (when in a safe state) or 33350 (when in OP). The logic comparing 33351 to either of these IDN's is an XOR.
- Digital Output Source Bitmask (33352)
  - has a similar role to 33351, except this IDN is compared to the output of 33351's XOR by using AND logic as shown in *Figure 10-5* . The combination of logic using comparisons to 33351 and 33352 can therefore be used to configure quite general logic.
- Digital Output User Configurable Default Safe State- General Purpose (33353)
  - is the default setting for the General Purpose digital output safe state (ie. when not in EtherCAT OP state) if all other bitmasking is set to pass this IDN's value straight through to 33345, and then to the digital outputs directly. *Figure 10-5* . shows that this default safe state value can be altered by 33351, 33352, and 33344. Recall that because it is General Purpose, its bit setting applies ONLY to those digital outputs for which a non-zero value in IDN 33350 has been chosen.
- Digital Output User Configurable Default Safe State- Hardware Level (33354)
  - is the default setting for the Hardware Level digital output safe state (ie. when not in EtherCAT OP state) if all other bitmasking is set to pass this IDN's value straight through to 33345, and then to the digital outputs directly. *Figure 10-5* shows that this default safe state value can be altered by 33354 and 33344. Recall that because it is a Hardware Level setting, its bit setting applies ONLY to those digital outputs for which a zero value in IDN 33350 has been chosen.

Software Requirements

- AMD drive firmware v2.033.001 or above

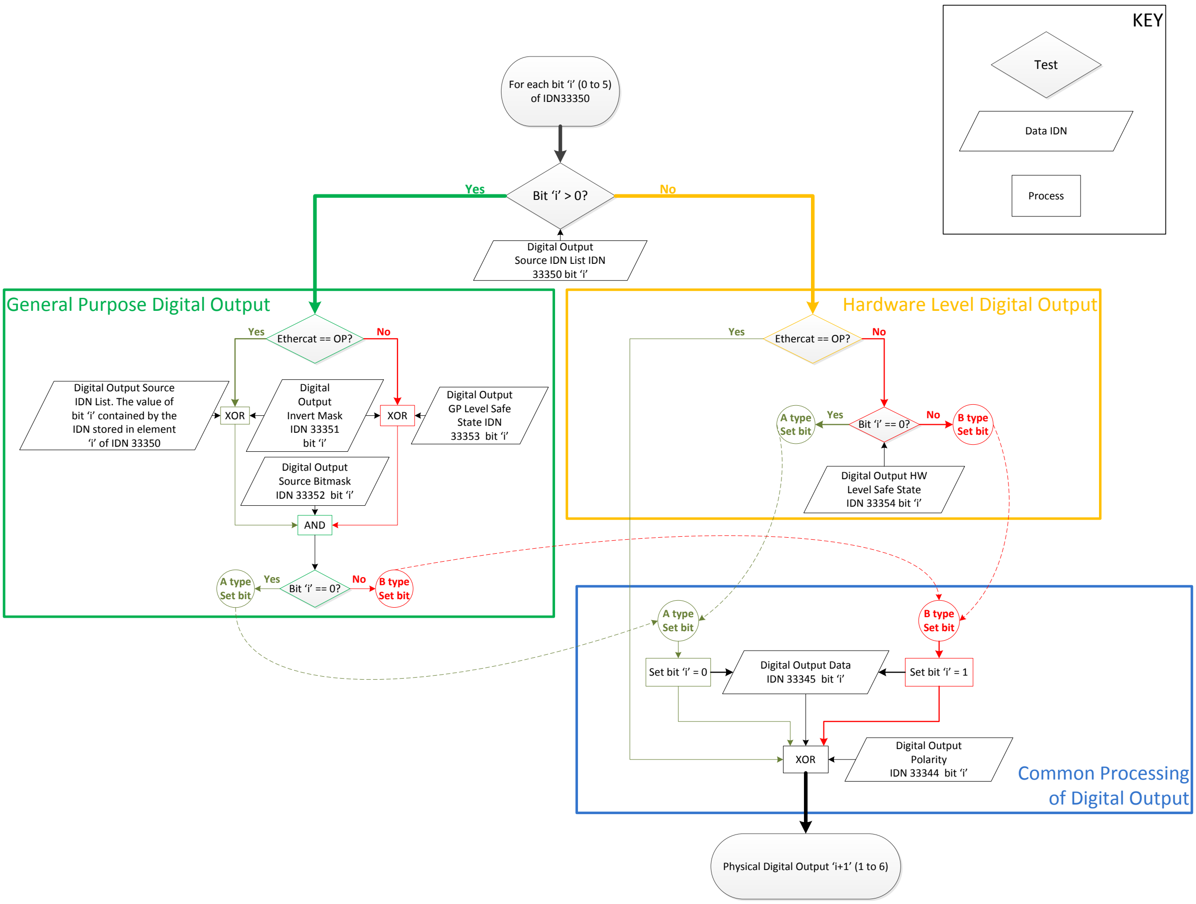


Figure 10-5 Digital Output Configuration Flow Chart

Equivalent Pseudo Code for *Figure 10-5*

```
for i = 0 TO 31
 if ( 33350[i] NOT EQUAL 0 ) AND ( *33350[i] IS U16 )
   if EtherCAT EQUAL OP
       if ( ( *33350[i] BITWISE XOR 33351[i] ) BITWISE AND 33352[i] ) NOT EQUAL 0
              33345(bit i) = 1;
       else
              33345(bit i) = 0;
       end
   else  // eg. SAFEOP, Pre-OP or INIT
       if ( (  33353[i] BITWISE XOR 33351[i] ) BITWISE AND 33352[i] ) NOT EQUAL 0
              33345(bit i) = 1;
       else
              33345(bit i) = 0;
       end
   end
 else
   if EtherCAT NOT EQUAL OP  // eg. SAFEOP, Pre-OP or INIT
       if 33354(bit i) NOT EQUAL 0
              33345(bit i) = 1;
       else
              33345(bit i) = 0;
       end
   end
 end
 PHYSICAL DIGITAL OUTPUT(i) = 33345(bit i) XOR 33344(bit i)
end
```

A note concerning bitwise operations

Truth table:

Input 1	Input 2	Bitwise XOR	Bitwise AND
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Bitwise XOR example:

Input 1	0101 1101 1000 1111
Input 2	1110 1010 0001 1010
Bitwise XOR	1011 0111 1001 0101

Bitwise AND example:

Input 1	0101 1101 1000 1111
Input 2	1110 1010 0001 1010
Bitwise AND	0100 1000 0000 1010

10.1.15 Drive Bypass Mode

Description

The drive supports a feature to set its Drive Status Word (IDN 135 / S-0-0135) as if the drive were enabled. This allows a drive to appear to be operational when in fact it is NOT. Uses for this feature include;

- the staging of drive power-up on a new machine (one drive at a time commissioning, where all drives may need to appear operational when testing the power-up sequences and evaluating their success),
- debugging a problematic drive, or
- the operation of a machine with a defective drive.

When the bypass mode is active and the master requests the drive to enable (via bits 13-15 of the Master Control Word (IDN 134 / S-0-134)), the drive issues a response as if the drive has enabled (via bits 3,14,15 of the Drive Status Word (IDN 135 / S-0-0135)); however, the drive stays in a disabled state. The drive's response concerning its operating mode (bits 8,9,10 of the Drive Status Word) will also mimic the requested operating mode (bits 8,9,11 of the Master Control Word). When in Bypass Mode all Class 1 Diagnostic Errors (C1D) are masked out.

IDN	Description
P-0-739 / 33507	Bypass mode toggle

To put a drive into bypass mode set IDN 33507 (P-0-739) to 1. To disable bypass mode set IDN 33507 (P-0-739) back to 0. Note that if the drive is already enabled, then the drive will remain in Bypass Mode until the drive is disabled and then re-enabled (e.g. e-stop, then reset). This variable can be accessed through the Advanced Parameter Access interface in ANCA MotionBench.

Software Requirements

- AMD drive firmware v2.032.001 or above

Note on IO

- General Purpose Digital and Analogue IO is unaffected by the drive being in Bypass Mode.

Warning: Since an axis which is in Bypass Mode will not move, there may be a risk of the machine joints crashing into each other.

Warning: Vertical axes where the motor brake is NOT controlled by the drive will likely fall if the axis is placed in Bypass Mode (for example, when the brake is controlled through a PLC). When the motor brake IS controlled by the drive, it will remain engaged even when in Bypass Mode.

10.1.16 Drive Data Logger

Description

The drive data logger can be used to synchronously sample data from the drives. Four variables can be logged simultaneously, each with up to 2048 data points. The method for triggering the log is quite flexible, utilising the following list of IDN's:

IDN	Label
P-0-1292 / 34060	Data Logger Procedure Command
P-0-1293 / 34061	Data Logger Variable List (4 element array)
P-0-1294 / 34062	Data Logger Sample Period Factor
P-0-1295 / 34063	Data Logger Pre-Trigger Samples
P-0-1296 / 34064	Data Logger Trigger IDN
P-0-1297 / 34065	Data Logger Trigger Mask
P-0-1298 / 34066	Data Logger Trigger Value
P-0-1299 / 34067	Data Logger Control Word
P-0-1300 / 34068	Data Logger Variable List Indices (4 element array)
P-0-1301 / 34069	Data Logger - Measured Signal - Channel 0
P-0-1302 / 34070	Data Logger - Measured Signal - Channel 1
P-0-1303 / 34071	Data Logger - Measured Signal - Channel 2
P-0-1304 / 34072	Data Logger - Measured Signal - Channel 3
P-0-1305 / 34073	Data Logger Error Word

Rather than provide a list of definitions for each of the above IDN's, an extensive description of the procedure for configuration, and some examples of configuration, are given below.

Software Requirements

- AMD drive firmware v2.036 or above

Procedure for configuring and executing data logging

To configure the drive data logger follow these steps. Note that ANCA MotionBench can be used for this task, and there is a figure describing its use at the end of this Section.

1. Specify the IDNs of the variables you wish to log. A complete listing is specified in the Digital Servo Drive Parameter Reference. Up to 4 may be specified:

   a. Specify the IDN for logging on channel 0 by placing the IDN of the variable of interest into the first element of the array contained by IDN P-0-1293 / 34061 (this element is considered to be element 0)
   b. Similarly specify IDN for channel 1: P-0-1293 / 34061 (element 1)
   c. Similarly specify IDN for channel 2: P-0-1293 / 34061 (element 2)
   d. Similarly specify IDN for channel 3: P-0-1293 / 34061 (element 3)

   Setting an element of IDN 34061 to 0 (zero) means that this channel will not be used during the data log. If the specified IDN refers to an array (rather than a single numeric variable), then additionally the index of the element of interest in that array should be specified in IDN 34068 as follows:

   a. Specify the IDN index into the array for channel 0: P-0-1300 / 34068 (element 0)
   b. Specify the IDN index for channel 1: P-0-1300 / 34068 (element 1)
   c. Specify the IDN index for channel 2: P-0-1300 / 34068 (element 2)
   d. Specify the IDN index for channel 3: P-0-1300 / 34068 (element 3)

   For IDNs which are **not** arrays then the index specified in 34068 should be 0 (zero).

2. Specify the period between samples. The period must be a whole multiple of the fundamental sample period of the drive (62.5µs). The factor is configured using P-0-1294 / 34062. Specifically:

$$\text{IDN } 34062 = \frac{\text{Sample Period}}{62.5\mu s}$$

For example, to log at:

   a. Task0: IDN 34062 = 62.5µs / 62.5µs = 1 (current loop update period)
   b. Task1: IDN 34062 = 250µs / 62.5µs = 4 (position / velocity loop update period)
   c. Task3: IDN 34062 = 4000µs / 62.5µs= 64 (CNC servo update period)

3. Configuring a trigger to control under what conditions the data log will cease. The trigger mechanism is quite flexible; the general idea is that any variable within the SoE Profile can be selected as the trigger variable, and the outcome of its comparison with a fixed value can be used to cease the data logging. The data logger is pre-configured to allow only 2048 samples to be collected, but the trigger mechanism allows the user to specify where within the 2048 samples the trigger level is to be detected. For example, the user may wish to commence sampling when a variable exceeds a certain threshold, or they may wish to log both prior to, and following a significant event, or they may wish to capture data prior to a certain point. All of these approaches utilise a single configuration in the AMD2000.

   The user begins by specifying the number of pre-trigger samples to log. The Drive Data Logger uses a circular buffer to store data. The pre-trigger samples parameter (P-0-1295 / 34063) informs the logger how many samples to keep prior to the trigger sample. In the following example, IDN 34063 is set to 500. This means that the buffers returned on completion of the data log will include 500 samples taken immediately before the trigger event occurred and 1548 after (for a total of 2048 data points):

   Pre-trigger Samples | Trigger Sample | Post-trigger Samples

0	**1**	…	**498**	**499**	**500**	**501**	…	**2046**	**2047**

4. The trigger variable's IDN is specified in P-0-1296 / 34064, and the fixed value for comparison and detection of the trigger event is specified in P-0-1298 / 34066. IDNs of many data types are supported, see notes in the following table for limitations, but these include signed 16-bit (S16), unsigned 16-bit (U16), signed 32-bit (S32) and unsigned 32-bit (U32). Several types of trigger comparison are supported. These types can be configured via bits 4-6 of the Data Logger Control Word (P-0-1299 / 34067) as shown below.

Comparison	IDN 34067 (bits 4-6)	Pseudo Code	Notes
Equal To	000	*34064 == 34066	
Not Equal To	001	*34064 != 34066	
Greater Than	010	*34064 > 34066	
Less Than	011	*34064 < 34066	
Absolute Greater Than	100	abs(*34064) > 34066	only S16 & S32
Absolute Less Than	101	abs(*34064) < 34066	only S16 & S32

   In addition, an optional bit mask (P-0-1297 / 34065) can be applied to the trigger variable to single out and compare individual bits (see table below). This is useful if the trigger variable (as pointed at by the IDN stored in IDN 34064) is a bitfield. Note that if IDN 34065 = 0 (zero), then this bit mask is disabled so the comparison reverts to a direct comparison between the trigger variable's value (*34064) and the fixed comparison value stored in IDN 34066.

Comparison	Pseudo Code	Notes
Equal To	(*34064 & 34065) == 34066	only U16 & U32
Not Equal To	(*34064 & 34065) != 34066	only U16 & U32
Greater Than	(*34064 & 34065) > 34066	only U16 & U32

Less Than	(*34064 & 34065) < 34066	only U16 & U32

Finally, if the variable pointed to by the trigger (IDN 34064) is an array, then the index of the element that should be used from this array can be specified via bits 8-11 of the Data Logger Control Word (P-0-1299 / 34067). Values up to array index of 15 are supported. For non-array variables, bits 8-11 should be set to 0.
If the user wishes to avoid using a specific trigger, and simply commence sampling, with completion at the end of 2048 samples, then it is possible to set bit 0 of the Data Logger Control Word (P-0-1299 / 34067) to 1. This will take precedence over all other triggering configurations and will commence the data logging as soon as the data logger is enabled (see below, point 5, for how to enable the logger).

5. The Drive Data Logger is enabled by setting (P-0-1292 / 34060) to 3.

6. The user can then read back the logged data from the 2048 element array stored for each variable from the following list of IDN's:
    a. Channel 0: P-0-1301 / 34069 <-- an IDN representing a 2048 element array
    b. Channel 1: P-0-1302 / 34070 <-- an IDN representing a 2048 element array
    c. Channel 2: P-0-1303 / 34071 <-- an IDN representing a 2048 element array
    d. Channel 3: P-0-1304 / 34072 <-- an IDN representing a 2048 element array

There are a number checks within the Drive Data Logger module to ensure that the specified configuration parameters, that were discussed above, are within acceptable bounds. Any violations are reported in the Data Log Error Word (P-0-1305 / 34073), and 5 such violations are as follows:

IDN 34073	Label
bit 0	Number of pre-trigger samples exceeds buffer length
bit 1	IDN specified for trigger is not valid
bit 2	IDN index specified for trigger is not valid
bit 3	Comparison operator is not valid
bit 4	Sample period factor is not valid

Example Usage

Trigger from Drive Stimulus Injection
Velocity response / current response in the frequency domain

Step 1: Specify the IDNs and IDN indexes to log, for example:

IDN 34061 [0] = 33006	Idq Current Command (IDN 33006)
IDN 34061 [1] = 33050	Idq Current Feedback (IDN 33050)
IDN 34061 [2] = 0	(not used)
IDN 34061 [3] = 0	(not used)
IDN 34068 [0] = 1	Element 1: Iq Current Command
IDN 34068 [1] = 1	Element 1: Iq Current Feedback
IDN 34068 [2] = 0	(not used)
IDN 34068 [3] = 0	(not used)

Step 2: Specify the sample period factor, for example:

IDN 34062 = 1	Log at Task0: 62.5µs / 62.5µs = 1

Step 3: Configure trigger, for example:

IDN 34064 = 34042	Use the Stimulus Status Word (IDN 34042) to trigger off
IDN 34065 = 3	Mask bits 0-1 of the Stimulus Status Word
IDN 34066 = 3	Compare to 3 (stimulus injection complete)
IDN 34067 = 0	Comparison type is "Equal To" (bits 4-6 = 000) and index into IDN 34042 is 0 (bits 8-11 = 0000)

Step 4: Specify the number of pre-trigger samples, for example:

IDN 34063 = 2047	Entire buffer contains the data before the trigger event occurred

Step 5: Enable the drive data logger, for example:

IDN 34060 = 3	Drive Data Logger Procedure Command

Trigger from Class 1 Diagnostic Fault
Capture data should a sporadic Class 1 Diagnostic (C1D) fault occur

Step 1: Specify the IDNs and IDN indexes to log, for example:

IDN 34061 [0] = 32961	Position Command (IDN 32961)
IDN 34061 [1] = 33625	Position Feedback (IDN 33625)
IDN 34061 [2] = 32962	Velocity Command (IDN 32962)
IDN 34061 [3] = 33626	Velocity Feedback (IDN 33626)
IDN 34068 [0] = 0	Element 0 (not an array)
IDN 34068 [1] = 0	Element 0 (not an array)
IDN 34068 [2] = 0	Element 0 (not an array)
IDN 34068 [3] = 0	Element 0 (not an array)

Step 2: Specify the sample period factor, for example:

IDN 34062 = 4	Log at Task1: 250µs / 62.5µs = 4

Step 3: Configure trigger, for example:

IDN 34064 = 33255	Class 1 Diagnostic (C1D) Error Status Word (IDN 33255)
IDN 34065 = 0	(disable mask)
IDN 34066 = 0	Compare to 0 (no C1D)
IDN 34067 = 16	Comparison type is “Not Equal To” (bits 4-6 = 001) and index into IDN 33255 is 0 (bits 8-11 = 0000)

Step 4: Specify the number of pre-trigger samples, for example:

IDN 34063 = 1024	First half of the data in the buffer is pre C1D Event and the second half is post C1D Event

Step 5: Enable the drive data logger, for example:

IDN 34060 = 3	Drive Data Logger Procedure Command

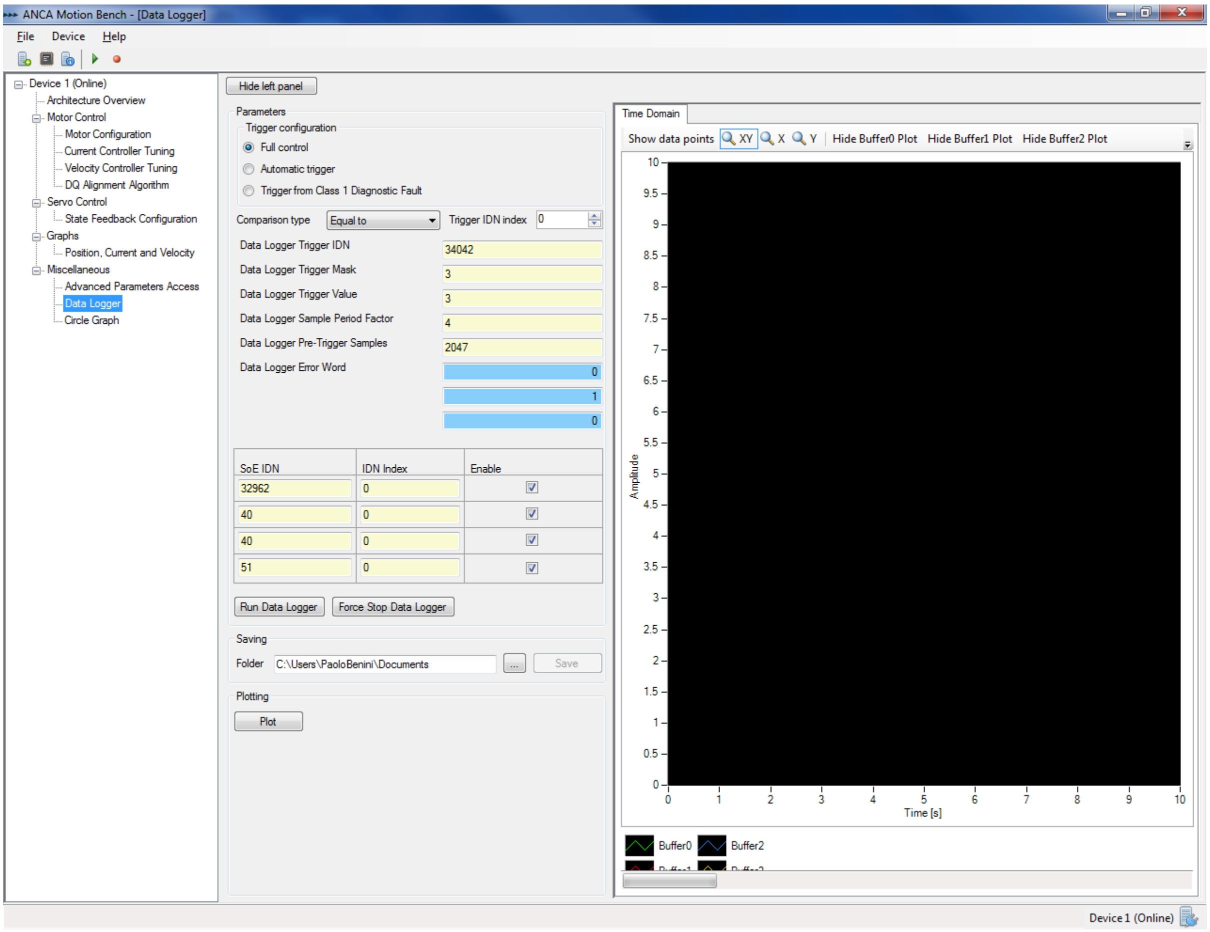


Figure 10-6 ANCA MotionBench Drive Data Logger Interface

10.1.17 Encoders

Description

The drive can be connected to up to two encoders, one on Channel 1, and a further encoder on Channel 2. Each channel supports connection to either of two encoder types, both of which are incremental, these are:

- Quadrature, or
- Analogue SINCOS

The encoders provide feedback information to the drive for closed-loop position or speed control and are also employed to some degree in current control. The encoder channels will be described using the terms “motor” and “external” encoder feedback in the discussion below, where the external feedback is often assigned to a linear scale or some other sensor that is closer to the tool tip, or end effector of the machine under operation. The motor encoder feedback is usually directly connected to the motor itself. Either of these feedbacks can be connected to either channel on the drive, with suitable configuration described below. Each channel needs to be configured separately.

Encoder Connection Setup

The drive needs to be configured to determine which channels are connected to an encoder. The user can set the following IDN’s to either of the following two values:

- 0: No encoder connected
- 10: Incremental encoder connected

IDN	Description
P-0-1432 / 34200	Encoder Type Connected - Channel 1
P-0-1433 / 34201	Encoder Type Connected- Channel 2

Furthermore, each channel needs to be specified as either “motor” encoder feedback, or “external” encoder feedback. The user can set the following IDN’s to either of two values:

- 0: Channel 1
- 1: Channel 2

IDN	Description
P-0-1028 / 33796	Motor Encoder Source Channel
P-0-1029 / 33797	External Encoder Source Channel

Motor Encoder Feedback

If IDN 33796 has been associated with a Channel (either 1 or 2) which has an encoder connected (ie. the channel’s IDN has been set to ‘Incremental encoder connected’) then further motor encoder can be configured such as;

IDN	Description
S-0-0116 / 116	Resolution of Motor Encoder
S-0-0121 / 121	Input Revolutions of Load Gear
S-0-0122 / 122	Output Revolutions of Load Gear
S-0-0123 / 123	Feed Constant
S-0-0277 / 277	Motor Encoder Feedback Type
P-0-0004 / 32772	Motor Encoder Control Word
P-0-0006 / 32774	Motor Poles Per Revolution

The type of Motor Encoder Feedback IDN parameters S-0-0277 / 277 and P-0-0004 / 32772, for specific bitfield details refer to the SoE parameters document

The resolution of an incremental motor encoder is defined via IDN S-0-0116 / 116. Given the input (S-0-0121 / 121) and output (S-0-0122 / 122) revolutions, the overall gear ratio is calculated. In addition the feed constant (S-0-0123 / 123) should be specified

Analogue Incremental Encoders Only

For analogue (SINCOS) encoders further information is required regarding the Sine and Cosine information in the channel. The two IDN's listed in the following table are each an array containing two elements. The first element in each IDN array relates to the Cosine information from the sensor, and the second element relates to the Sine information, so their respective descriptions for each IDN use the terminology "CosSin" to reflect this particular ordering of the input information. IDN 33803 allows the user to configure the gain applied to the analogue inputs for each of the Cosine or Sine inputs. IDN 33804 is similarly configured for offsets from zero.

IDN	Description
P-0-1035 / 33803	Motor Encoder CosSin Gain
P-0-1036 / 33804	Motor Encoder CosSin Offset

External Encoder Feedback

If IDN 33797 has been associated with a Channel (either 1 or 2) which has an encoder connected (ie. the channel's IDN has been set to 'Incremental encoder connected') then further external encoder details can be configured such as;

IDN	Description
S-0-0115 / 115	External Encoder Feedback Type
S-0-0117 / 117	Resolution of Rotary External Encoder
S-0-0118 / 118	Resolution of Linear External Encoder
P-0-0005 / 32773	External Encoder Control Word

The external encoder is usually the feedback device attached at the end effector. Encoder details must be configured via parameters S-0-0115 / 115 and P-0-0005 / 32773, for specific bitfield details refer to the SoE parameters document.
The resolution of an incremental external encoder is defined via S-0-0117 / 117 for rotary encoders and S-0118 / 118 for linear encoders. Again, please refer to the SoE parameters document for details .

Analogue Incremental Encoders Only

For analogue (SINCOS) encoders further information is required regarding the Sine and Cosine information in the channel. The two IDN's listed in the following table are each an array containing two elements. The first element in each IDN array relates to the Cosine information from the sensor, and the second element relates to the Sine information, so their respective descriptions for each IDN use the terminology "CosSin" to reflect this particular ordering of the input information. IDN 33843 allows the user to configure the gain applied to the analogue inputs for each of the Cosine or Sine inputs. IDN 33844 is similarly configured for offsets from zero.

IDN	Description
P-0-1075 / 33843	External Encoder CosSin Gain
P-0-1076 / 33844	External Encoder CosSin Offset

10.1.18 Field Orientation Initialisation

Description

A motor rotates due to the forces of attraction/repulsion between magnetic fields situated on the rotor and the stator where these fields can be generated in a number of different ways. The torque applied to the rotor is a resolved component of these forces acting *around* the motor shaft. It is proportional to the flux density of the magnetic fields, as well as a number of other parameters. Where electrical windings are used to generate these magnetic fields, the field's flux density is proportional to the current flowing through the winding.

One mechanical revolution of the rotor is usually more than one complete cycle traversing all the winding phases. That is to say, the sequence of electrical windings for each phase of electricity driving the motor is usually repeated more than once around the circumference of the motor. Hence, if a single vector is used to collectively represent the current for all these electrical phases, it must traverse a full 360 'electrical' degrees a number of times (depending on number of times the phase winding repeat) before completing one mechanical revolution. It is possible to represent such a single current vector as two component parts; one "quadrature" current, and a "direct" current. The "quadrature" component of the current vector is most closely associated with the magnetic forces that act *around* the motor shaft, and reaches its highest value when the electrical angle between the stator and rotor magnetic fields is near 90 degrees. For optimum torque delivery and motor efficiency, it is essential to keep this "field angle" at 90 degrees. The algorithm for doing this task is called commutation.

For Permanent Magnet AC (PMAC) motors, successful commutation requires correct initialisation wherein the rotor field angle is determined relative to a reference position on the stator. This initialisation has many names, for example: commutation initialisation, field orientation initialisation, phase initialisation. In the AMD2000 drives it is known as Field Orientation Initialisation (FOI).

It will be noted that in AMD2000 drives, the reference position is aligned with the back-EMF U-phase.

AMD2000 drives support several FOI techniques. These are called:

- *DQ* Alignment
- *Acceleration Observer*
- *Analogue Commutation Track*
- *Hall Effect Sensor*

For the above FOI techniques;

- *DQ Alignment* and *Acceleration Observer* can always be used for motors with an incremental encoder (The AMD2000 does not support absolute encoders at this time).
- *Analogue Commutation Track* is recommended for motors with incremental analogue encoders that have commutation tracks, typically found on braked motors;
- *Hall Effect Sensor* is recommended for motors with Tamagawa (UVW wire saving encoders).

Table 10-1 below lists the possible FOI options for different encoders. It should be noted that to further improve FOI accuracy for some techniques, post processing (*Alignment Off Index Pulse*) can be conducted for incremental encoders that possess such an indexing pulse.

Table 10-1 Encoder Types and Possible FOI Algorithms

Encoder Type	FOI Techniques			Post Processing
	DQ Alignment	*Analogue Commutation Track*	*Acceleration Observer*	*Alignment Off Index Pulse*
Incremental	✓		✓	✓
Incremental with analogue COM track	✓	✓	✓	✓

The following table shows the list of IDN's relevant to FOI configuration and described in further detail below.

IDN	Label	Units
S-0-0051/51	PEST_s32Position_Feedback_1	[10-4 mm]
S-0-0116/116	MCPOS_u32Motor_EncRevsPerMechRev	NA
P-0-0006/32774	MCPOS__u16ElectricalPoles_Per_Rev	NA
P-0-0238/33006	ICONT_as32Idq_Cmd	[mA]
P-0-0249/33017	VCONT_s16PWM_VectorTime	[2-14 % of VDCBus]
P-0-0282/33050	CMNT_as32Idq_Estim	[mA]
P-0-0285/33053	CMNT_s32ThetaComm	[10-4 elec rev]
P-0-0289/33057	MCFO_boThetaElec_IndexPulseOffset_Evaluated	NA
P-0-0290/33058	MCFO_s32ThetaElec_IndexPulseOffset_Threshold	[10-4 elec rev]
P-0-0291/33059	MCFO_s32ThetaElec_Offset_Estim	[10-4 elec rev]
P-0-0292/33060	MCFO_en16DQAlignment_Ctrl	NA
P-0-0294/33062	MCFO_en16IndexPulseOffset_Ctrl	NA
P-0-0295/33063	MCFO_s32ThetaElec_IndexPulseOffset_Estim	[10-4 elec rev]
P-0-0296/33064	MCFO_s32ThetaElec_IndexPulseOffset	[10-4 elec rev]
P-0-0297/33065	MCFO_en16FieldOrientationInit_Type	NA
P-0-0298/33066	MCFO_s32ThetaElec_PresetOffset	[10-4 elec rev]
P-0-0301/33069	MCDQA__s32DQAlignment_Current	[mA]
P-0-0303/33071	MCDQA__s32DQAlignment_Current_Tolerance	[mA]
P-0-0305/33073	MCDQA__as32ThetaElec_TestAngles	[2-24 elec rev]
P-0-0312/33080	MCPA_en16AbsoluteFeedback_Type	NA
P-0-0596/33364	HWADC_au16EncoderCosSin_Com_Sample	[16 bits ADC counts]
P-0-1039/33807	MCPOS_s32ThetaElec_Estim_Motor	[10-4 elec rev]
P-0-1132/33900	MCFOJ_s32Stimulus_Amplitude	[mA]
P-0-1133/33901	MCFOJ_s32Stimulus_Frequency	[10-4 Hz]
P-0-1135/33903	MCFOJ_u16SM_RepeatCount	NA
P-0-1136/33904	MCFOJ_u16SM_StimulusTime	[T1]
P-0-1137/33905	MCFOJ_s32ThetaMech_MaxDeviation	[10-4 Mech rev/sec]
P-0-1138/33906	MCFOJ_u16PhaseEstimator_ThetaDelay	[T1]
P-0-1142/33910	MCFOJ_en16TorqueEstim_Model	NA
P-0-1145/33913	MCFOJ_s32TorqueEstim_J	[kg.mm2]
P-0-1146/33914	MCFOJ_s32TorqueEstim_K	[2-8 Nm/mech rev]
P-0-1439/34207	HWENC_as32EncoderCount_Index	[counts]

DQ Alignment

DQ Alignment injects magnetising current into the motor windings, resulting in the rotor moving to align with the stator magnetic field. This resulting position is latched and used to determine the correct offset. To verify the alignment, the motor commutation angle is commanded to move to seven different positions in order to verify the expected rotor movements. The default values for these seven positions [in electrical revolutions], as defined by IDN 33073 are:

- 0.0
- 0.3
- 0.6
- 1.0
- 0.7
- 0.5
- 0.0

With the above default values, a PMAC motor will move 360/(motor poles/2) [mechanical degrees] during DQ Alignment FOI. For a motor with 12 poles, this is 60 [mechanical degrees].

> **Warning:** Care should be taken to ensure that the resulting test move will not result in a mechanical collision.

Table 10-2 below lists the DQ Alignment configuration parameters.

Table 10-2 Configuration parameters for DQA algorithm considering alignment off index pulse

IDN	Name	Default Value	Unit	Note
33060	FOI Control	1 or 2		1: FOI once, 2: FOI on every re-enable
33065	FOI Type	1		1: DQ Alignment
33069	Alignment Current	3000	[mA]	axis/motor specific, may need to be adjusted

Note that:

- IDN 33060 can be set to 1 or 2 for activating DQ Alignment when the drive is first enabled after power-on, or every time the drive is re-enabled, respectively.
- IDN 33065 is set to 1 for choosing DQ Alignment technique.
- IDN 33069 set to 3000 [mA] is typically a good starting point for servo motors sized for most machining applications. It might need to be adjusted for other applications.

Error messages
The following errors might occur during DQ Alignment FOI.

E403: DQ Alignment Invalid Movement Detected
Motor movement error (the difference between the commutation angle and the measured electrical angle) exceeded specified tolerance (0.15 elec rev or 54 elec deg). This error is usually triggered by the motor not moving, moving too far or not enough, or moving in the wrong direction.

E405: DQ Alignment Current Control Error
Alignment current error (the difference between the command and measured motor current) exceeded specified tolerance (IDN 33071). This error may be caused by sensor failure, current loop poorly tuned, Safe Torque Off (STO) or motor/cable fault.

Procedure for testing / diagnosing faults with DQ Alignment FOI
Ensure configuration parameters are correct before starting the tests.
Note that:

- For the convenience of discussion, x-axis is used in this section as an example.

Step 1: Activate log_DQA1.cmd and enable the x-axis.
Step 2: If DQ Alignment fails due to Error 402 (DQ Alignment Invalid Movement Detected), check the logged data ThetaCmd_1.dat and ThetaFb_1.dat. Otherwise go to **Step 3**.

Note that:

- ThetaCmd_1.dat (IDN 33053) is the electrical angle command in [10^{-4} elec rev], and
- ThetaFb_1.dat (IDN 33807) is the electrical angle feedback in [10^{-4} elec rev]

Normally ThetaFb_1.dat follows ThetaCmd_1.dat as illustrated in *Figure 10-7* . When DQ Alignment fails and the axis trips out with Error 402, ThetaFb_1.dat does not follow ThetaCmd_1.dat anymore. This is likely due to:

- Incorrect motor poles IDN 32774 or/and incorrect encoder resolution IDN 116 (*Figure 10-8*), or/and
- Incorrect phase sequence (see *Figure 10-9*)

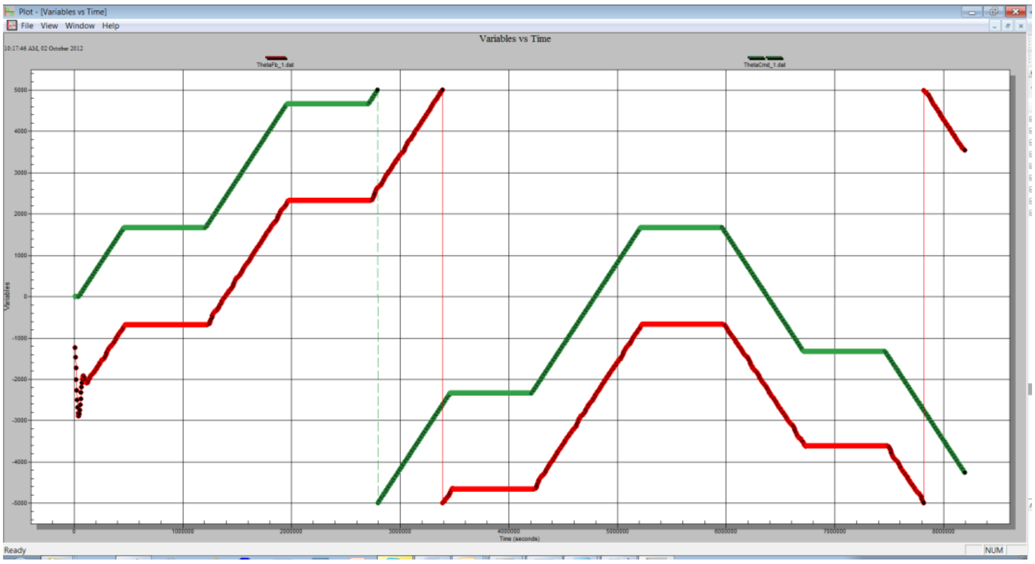


Figure 10-7 ThetaFb follows ThetaCmd correctly

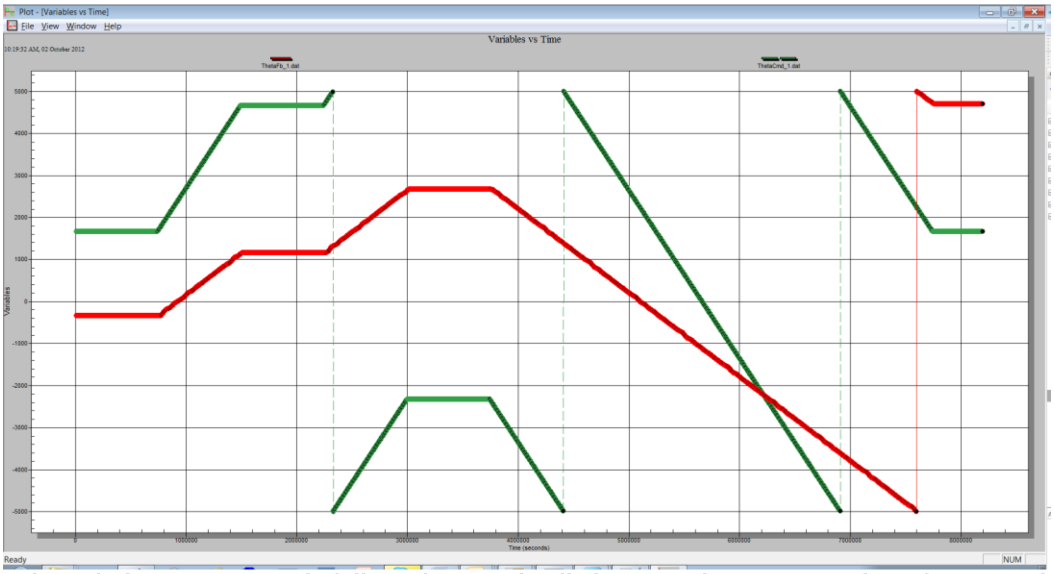


Figure 10-8 ThetaFb does not correctly follow ThetaCmd. Likely cause: incorrect number of motor poles (IDN 32774) and/or incorrect encoder resolution (IDN 116).

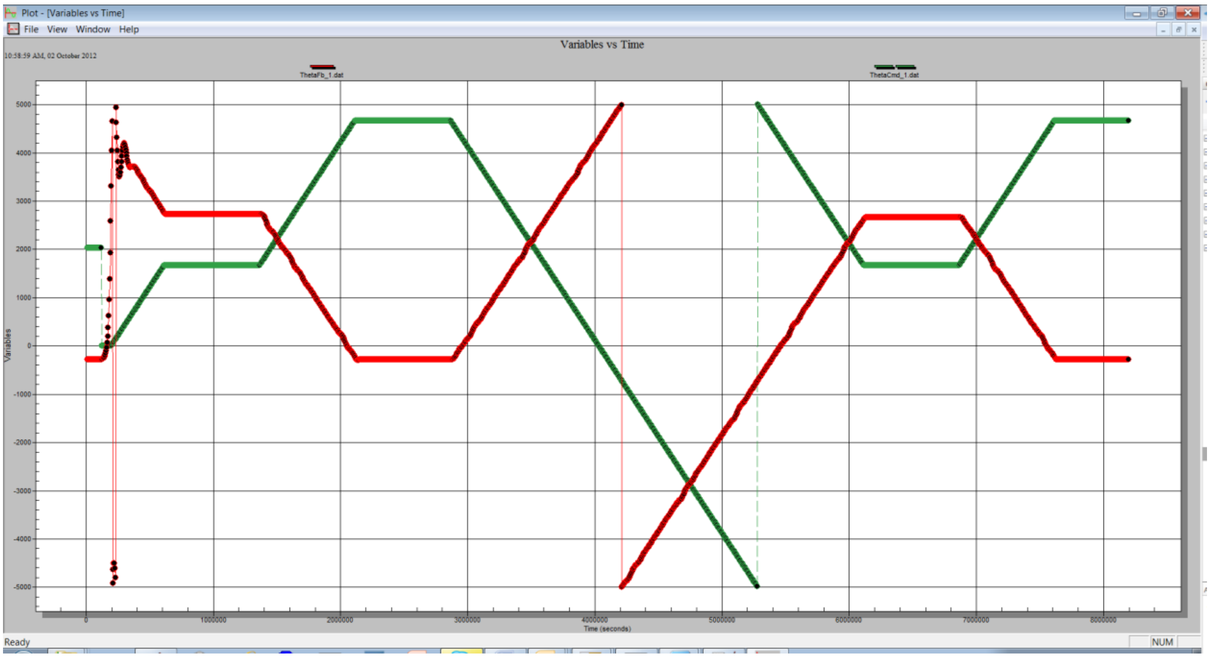


Figure 10-9 ThetaFb moves in opposite direction to ThetaCmd. Likely cause: incorrect motor phase sequence or inverted encoder feedback.

Step3. If the DQ Alignment fails due to Error 405 (DQ Alignment Current Control Error), check following logged data:

- idCmd_1.dat and
- idFb_1.dat

Otherwise go to Step 4.

Note that

- idCmd_1.dat in [mA] is the d-axis current command (IDN 33069), and
- idFb_1.dat in [mA] is the d-axis current feedback

Figure 4 below shows a plot of idCmd_1.dat and idFb_1.dat logged during a successful DQA FOI. It is seen that idFb_1.dat follows idCmd_1.dat. When the drive triggers E405, idFb_1.dat does not follow idCmd_1.dat. In this case, check the following:

- DC bus powered.
- Safe Torque OFF (STO) connector wired correctly.
- Current loop properly tuned.

It is also recommended that IDN 33017 be logged together with idCmd_1.dat and idFb_1.dat. If IDN 33017 [2-14 %VDCB] is a value above 90% but idFB_1.dat is close to zero, then either the DC bus is powered or the STO connector is not wired correctly.

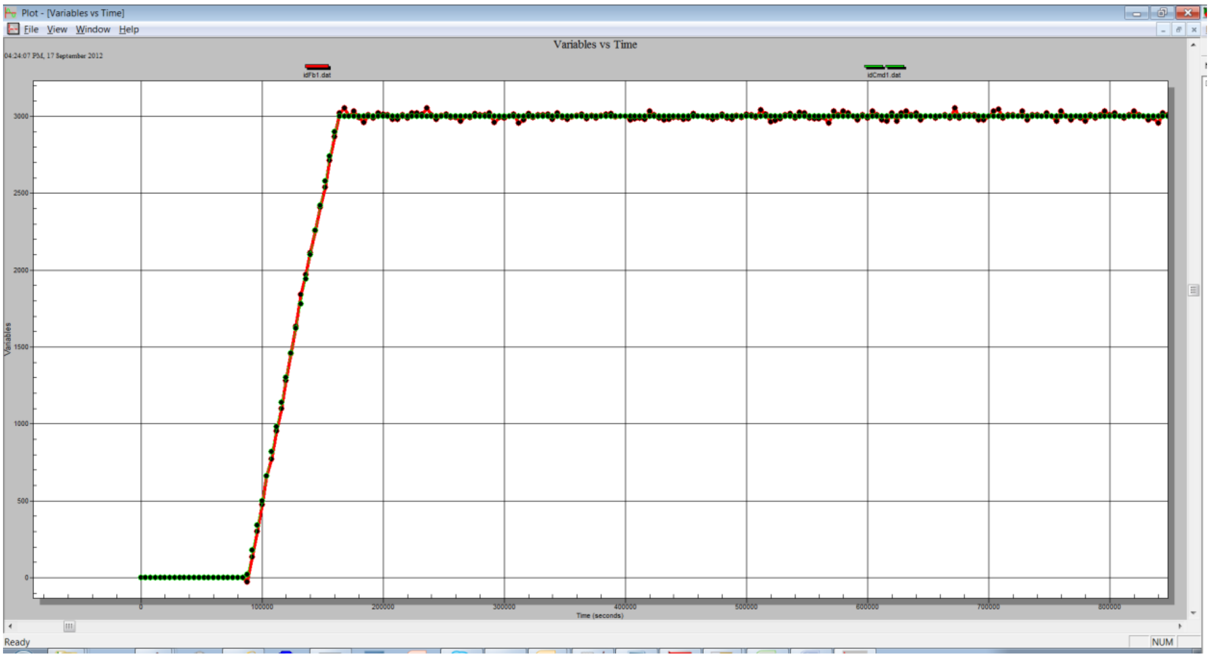


Figure 10-10 idCmd_a.dat and idFb_1.dat during a successful DQA

Alignment Off the Index Pulse

For motors with an incremental encoder, it is possible to align the electrical angle off the index pulse in order to improve the accuracy of electrical angle. To this end, the *index pulse offset* (namely the distance between the index pulse and zero degree of electrical angle) needs to be commissioned for each individual motor and encoder assembly. If the encoder is replaced, it will need to be re-commissioned. Failure to properly configure this feature can result in axis runaway.
Table 10-3 below lists the configuration parameters.

Table 10-3 Configuration parameters for alignment off index pulse

IDN	Name	Default	Unit	Note
33058	Index Pulse Offset Maximum Deviation Threshold	1700	[10^{-4} elec rev]	
33060	Field Orientation Initialisation Control			0: none 1: once 2: always
33062	Alignment Off Index Pulse Control	0		0: disable 1: commissioning 2: enable
33064	Index Pulse Offset	0	[10^{-4} elec rev]	

Procedure for commissioning and enabling alignment off index pulse

Step1: Determine the angle between the index pulse and the *d*-axis, that is, the *index pulse offset*.

1. Ensure that the drive is disabled.
2. Set *Alignment Off Index Pulse* to *Commissioning Mode* (IDN 33062 = 1).
3. Set *FOI Control* to *Always* (IDN 33060 = 2).
4. Set *FOI Type* to *DQ Alignment* (IDN 33065 = 1).
5. Monitor *Index Pulse Offset Evaluation* (IDN 33057) and *Index Pulse Offset Estimate* (IDN 33063).
6. Enable the drive and allow the *DQ Alignment* algorithm to complete. At this stage IDN 33057 should be zero. Slowly jog the axis until the index pulse is found (IDN 33057 = 1). Take a record of IDN 33063. Disable the drive, and then repeat this step to ensure that the calculated *Index Pulse Offset Estimate* (IDN 33063) is repeatable.

Step2: Enable alignment off index pulse.

1. Ensure that the drive is disabled.
2. Set *Index Pulse Offset* (IDN 33064) to the value of *Index Pulse Offset Estimate* (IDN 33063) that was determined in the previous step.

3. Set *Alignment Off Index Pulse* to *Enable* (IDN 33062 = 2).
4. Set *FOI Control* to *Once* (IDN 33060 = 1).

Once this procedure is complete, on subsequent power cycles of the drive the alignment angle will automatically be corrected once the index pulse is located.

Error messages

E403: Alignment Off Index Pulse Error

The commissioned index pulse offset value (IDN 33064) is determined by a machine commissioner. Upon machine power up the motor will execute Field Orientation Initialisation to achieve field alignment. Subsequent to this, and once the index pulse has been located, a new estimate off the index pulse offset (IDN 33063) is calculated. This error is produced when the difference between this estimate (IDN 33063) and the commissioned value (IDN 33064) exceeds the tolerance defined by IDN 33058, where the default value is 0.17 [elec rev]. Possible cause of this error is:

- incorrect encoder configuration by the commissioner (i.e. UVW hexant binary);
- a change in the stored commissioned value; and/or
- a change in the hardware configuration (relative movement between the motor and encoder).

Analogue Commutation Tracks

Analogue commutation tracks (sinCOM / cosCOM) of an incremental encoder are typically aligned with the index pulse, namely the index pulse is located at zero degree of the commutation track. Hence rotor electrical angle can be determined based on the commutation tracks, if the offset angle between index pulse and the stator magnetic field is known. Typically this offset angle is zero, if this is not the case, then an offset can be added using IDN 33066.

For illustrative purpose, *Table 10-4* below lists the key parameters for configuring Commutation Track FOI. It is important to note that ID33066 is set to 0.

Table 10-4 Configuration parameters for Use analogue commutation tracks FOI algorithm

IDN	Name	Value	Unit	Note
33060	Field Orientation Initialisation Control	1		0: none 1: once 2: always
33065	Field Orientation Initialisation Type	3		1: DQ Alignment 2: Preset Offset 3: Absolute 4: Acceleration Observer
33066	MCFO_s32ThetaElec_Preset Offset	0	[10^{-4} elec rev]	Typically zero is the correct value
33080	Absolute Feedback Type	1		0: None 1: Commutation track 2: Hall sensor

Error messages

E406: Absolute Encoder Alignment Error.

An error has occurred reading the absolute encoder data. Check the COM Track signal integrity.

E013: Commutation Track Amplitude Low

The amplitude of the encoder commutation track signals ($\cos^2 + \sin^2$) is below the minimum limit, which is 10000. That is, the following condition is true

$(ID33364[0] – 32768)^2 + (ID33364[1] – 32768)^2 < 10000^2$

E014: Commutation Track Amplitude High

The amplitude of the encoder commutation track signals ($\cos^2 + \sin^2$) is below the minimum limit, which is 32700. That is, the following condition is true

$(ID33364[0] – 32768)^2 + (ID33364[1] – 32768)^2 > 32700^2$

Acceleration Observer

The *Acceleration Observer* technique is a minimum displacement FOI, meaning that it is suited to applications where excessive moment on the motor during initialisation is not acceptable.

The general idea of this technique is to inject *d*-axis current and repeatedly sweep the commutation angle through 360 degrees. The frequency of the commutation angle must be fast enough so that the motor does not begin tracking the rotating magnet field, but slow enough to ensure acceptable convergence of the algorithm. Given this, the algorithm consists of the following major components:

1. Stimulus generation: generate *d*-axis current with defined amplitude and frequency;
2. Data acquisition: measure the motor reaction (electrical displacement) as a result of the stimulus;
3. Torque estimation: estimate electrical torque as a function of electrical angle; and
4. Alignment angle offset estimation: estimate the electrical angle offset for optimum torque generation and efficiency.

Table 10-5 below lists the Acceleration Observer configuration parameters.

Table 10-5 Configuration parameters and default values for Acceleration Observer FOI

IDN	Name	Value	Units	Note
33060	Field Orientation Initialisation Control	1		0: none 1: once 2: always
33065	Field Orientation Initialisation Type	4		1: DQ Alignment 2: Preset Offset 3: Absolute 4: Acceleration Observer
33900	Stimulus Amplitude	3000	[mA]	
33901	Stimulus Frequency	800000	[10^{-4} Hz],	
33903	Stimulus Repeat Count	10		
33904	Stimulus Time	500	[T1]	
33905	Motor Movement Maximum Deviation	2000000	[10^{-4} mech rev]	
33906	Phase Estimator Correction	2	[T1]	
33910	Torque Estimator Model Type	0		0: Inertia 1: Compliant
33913	Torque Estimator Model Inertia	99	[kg.mm^2]	
33914	Torque Estimator Model Stiffness	25600	[2^{-8} Nm/mech rev]	

Suggestions for selecting key parameters

- Torque estimator model type:
  - For unbraked motors:
    - Use inertia model (IDN 33910 = 0) for estimating torque.
    - Axis inertia (IDN 33913) does not need to be exact; typically a larger value will ensure that a suitable torque estimate as a function of stimulus electrical angle is achieved.
  - For braked motors:
    - Use compliant model (IDN 33910 = 1) for estimating torque.
    - Axis stiffness (IDN 33914) does not need to be exact; typically a larger value will ensure that a suitable torque estimate as a function of stimulus electrical angle is achieved.
- Stimulus configuration:
  - Stimulus amplitude (IDN 33900) should be selected using trial and error. Start with a small value and then gradually increased in small steps. A large amplitude can result in excessive vibration and mechanical damage.
  - Stimulus frequency (IDN 33901) should be selected using trial and error. Start with a large value and then gradually reduce in small steps. A small value may result in the motor tracking the rotating magnet field; resulting in excessive displacement. In short, the stimulus frequency must be well above the axis position-loop bandwidth.
  - Test time = IDN 32904 x IDN 33903 [250us]. For example, if IDN 32904 = 750 and IDN 33903 = 10, then the test time = 1.875 [sec].

Error messages

E414: Acceleration Observer Torque Response Amplitude Low

The fundamental frequency component of the torque response is below the minimum amplitude threshold (0.1 Nm). The system may not have been stimulated correctly and hence the alignment estimate may not be accurate.

E415: Acceleration Observer Torque Response Amplitude High
The fundamental frequency component of the torque response is above the maximum amplitude threshold (2 Nm). The system may not have been stimulated correctly and hence the alignment estimate may not be accurate.

E416: Acceleration Observer Torque Response Mean Squared Error
The difference between the predicted torque and the estimated (measured) torque is greater than the threshold (1 Nm).

10.1.19 Higher Level Functions

Description

The AMD2000 allows the user to select different motion control approaches as Higher Level Functions. These are described as follows;

1. Numerical Control (NC) – this is the default function for the drive's higher level motion control and can be configured to use position, velocity, or torque control. The choice of set point command is made using the Operation Modes discussed in section *10.1.23 Operating Modes* of this document. The information concerning the movement profile and objectives is contained in the SoE profile data. This choice of control requires an external entity or control unit for supplying the profile data.
2. Drive-Controlled Homing (DCH) – A homing routine can be executed by the drive in standalone operation (i.e. without an external control unit). The position feedback is connected to the drive via one of the two available encoder channels. The home switch is connected to the drive. The home offset and distance is calculated and retained by the drive.
3. Control Unit Controlled Homing (CUCH) – A homing routine for the drive that requires control from an external control unit (e.g. CNC software on a PC). The home offset and distance is calculated and written to the drive by the control unit.
4. Drive Controlled Moves (DCM) – The drive may be set to follow a sequence of pre-defined moves stored in the drive and configurable by the user.
5. Drive Controlled Stroking (DCS) – the drive undergoes a number of cyclic moves in order to aid tuning procedures, and for other specific applications that might require such moves.

The AMD2000 defaults to using NC as its higher level function (for details of the Operation Modes settings, and the nature of the servo controller. The user may configure "procedure commands" to enable DCH, CUCH, DCM or DCS. These alternative higher level functions take precedence over NC if they are asserted. Care must be exercised as it is possible, in some cases, to assert more than one function at a time. Upon completion of such procedure commands, however, the drive will return to NC automatically.

Warning: Care must be exercised so that only one higher level function is being executed at any point in time, otherwise unexpected behaviour may result.

Drive Controlled Homing

Drive Controlled Homing (DCH) is typically used when a control unit (i.e. CNC) is not present. To execute DCH, the following conditions shall be valid:

- Position feedback is connected to the drive via one of the two available encoder inputs.
- The home switch is connected directly to the drive via one of its digital inputs.
- The home offset displacement is to be calculated internal to the drive.

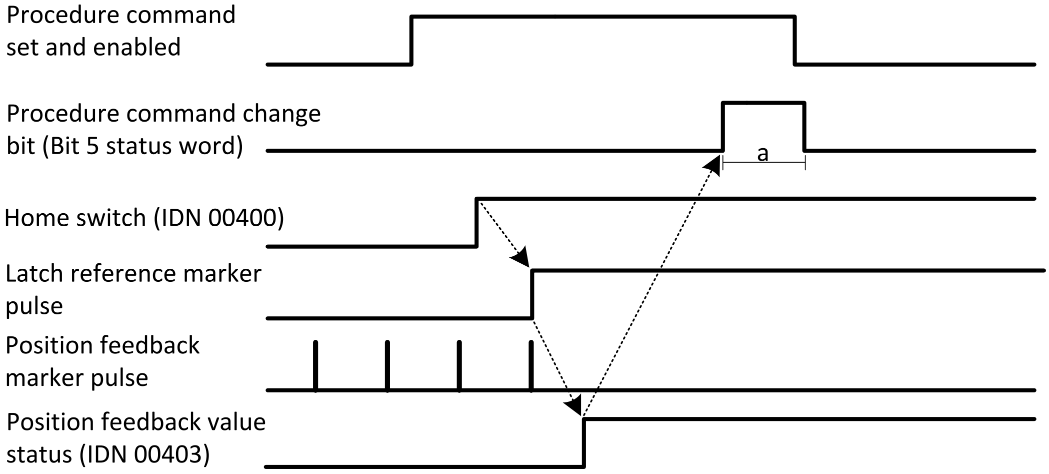


Figure 10-11: Drive-controlled homing

DCH is managed through various settings of the following IDN's:

IDN	Label
S-0-0041 / 41	Homing Speed – to Home Switch
S-0-0042 / 42	Homing Max Acceleration
S-0-0052 / 52	Reference Distance 1
S-0-0054 / 54	Reference Distance 2
S-0-0147 / 147	Homing Parameter
S-0-0148 / 148	Drive Controlled Homing Procedure Command
S-0-0150 / 150	Reference Offset 1
S-0-0151 / 151	Reference Offset 2
S-0-0403 / 403	Position Feedback Value Status
P-0-0432 / 33200	Extended Homing Parameter
P-0-0437 / 33205	Homing Speed – to Index Pulse
P-0-0438 / 33206	Homing Runoff Distance
P-0-0439 / 33207	Drive Controlled Homing Procedure Command Acknowledge

The DCH function is configured and executed by the following steps, and is illustrated in terms of logic levels in Figure 10-11:

1. The DCH uses two numbers to relate an axis home position relative to a machine zero position.
   a. The 'reference distance' describes what may be considered the "best" sensor estimate for a valid home position for the drive's associated machine axis. In order to find this distance the axis is driven to one of its limits of allowed motion, often a probe/proximity sensor that is called the "home switch It is then reversed away from this limit until it detects an index pulse coming from its associated encoder (usually from the motor encoder, but not always). This position is now set internally as the reference distance, and its value is made available for each end of an axis as 1 and 2 through the IDN's S-0-0052/52 and S-0-0054/54.
   b. It is sometimes useful for a machine that is being 'homed' to travel a further fixed distance away from the above 'reference distance' in order to finally be considered as at home position. This is called the 'reference offset', and can be set for each end of an axis as 1 and 2 by configuring the value of the IDN's S-0-0150/150 or S-0-0151/151.[5]

   These parameters may need to be re-commissioned (i.e. Changed) whenever the motor or encoder setup has changed.

Warning: Care must be exercised so that all homing related IDN's are suitably configured whenever hardware (e.g. motor or encoder) changes are made, since unexpected behaviour may result.

2. Start the DCH higher level function execution by setting the DCH procedure command IDN S-0-0148/148 to a value of 3.
3. The axis will then move to the home switch, following a velocity profile that uses a programmed homing speed (S-0-0041/41) and de-/acceleration (S-0-0042/42). The direction in which to home is set via IDN S-0-0147, and the particular bit settings are specified in the accompanying document "Digital Servo Drive SoE Parameter Reference" (dd_reference_SoE_parameter.pdf)
4. The axis will then move off the home switch by a distance defined by the homing runoff distance (P-0-0438/33206), note the sign of this runoff distance (+/-) affects the direction the axis travels when it moves off the home switch.
5. Once at the runoff distance, the axis will then commence to move at home speed (to index pulse) (P-0-0437/33205) in the direction specified by the sign of this speed, until an index pulse is registered from the associated encoder. If homing off the home switch (not index pulse), this step is skipped.

[5] This 'reference offset' does NOT currently get used by the AMD2000, it may do so in future releases.

6. The drive then sets its reported position at this point as relative to machine zero by the amount set in either of IDN's S-0-0052/52 and S-0-0054/54. Under some conditions it is possible for DCH to then order the drive to execute a further move to the reference offset position before considering itself to be at home, however the AMD2000 does to currently implement this final offset repositioning that would usually result in a move as specified by IDN's S-0-0150/150 or S-0-0151/151.
7. At the completion of homing, the status actual position value (S-0-0403/403) is set to flag the successful completion of the DCH function.
8. The IDN S-0-0148/148 must now be reset to 0 by an external entity, or the drive will remain in the DCH state of operation, and will not subsequently move or respond until this action is completed.

For more details regarding each parameter, refer to the "Digital Servo Drive SoE Parameter Reference" (dd_reference_SoE_parameter.pdf).

The DCH function can be performed at almost any time by activating the DCH function again (via procedure command S-0-0148/148 being set to 1). Therefore care must be exercised that DCH does not become activated while the drive and associated axis are executing other tasks.

Warning: Care must be exercised so that the DCH function is NOT activated while the axis is already in motion, or committed to performing other tasks, since unexpected behaviour may result.

Control Unit Controlled Homing

Control Unit Controlled Homing (CUCH) requires the Homing Enable IDN S-0-0407/407 to be set by an external control unit (e.g. a CNC). The drive also sets up the calculated offset at the end of a successful homing execution so that future position commands are referenced to the machine zero. The home switch may be connected to either the control unit or the drive via the appropriately configured digital inputs.

There are three configurable use cases that the control unit may select for implementation of CUCH:
1. Control unit detection of homing, and calculation of homing data,
2. Drive amplifier detection of homing, but Control unit calculations of homing data, or
3. Drive amplifier detection of homing, and calculation of homing data.

The following IDN's are relevant to CUCH configuration and operation:

IDN	Label
S-0-0052 / 52	Reference Distance 1
S-0-0054 / 54	Reference Distance 2
S-0-0146 / 146	Control Unit-Controlled Homing Procedure Command
S-0-0147 / 147	Homing Parameter
S-0-0150 / 150	Reference Offset 1
S-0-0151 / 151	Reference Offset 2
S-0-0171 / 171	Calculate Displacement Procedure Command
S-0-0172 / 172	Set Reference Point Procedure Command
S-0-0175 / 175	Displacement Parameter 1
S-0-0403 / 403	Position Feedback Value Status
P-0-0422 / 33190	Use a Digital Input in Place of an Index Pulse for Homing

Case 1: the home switch is connected to the control unit and the control unit makes calculations.

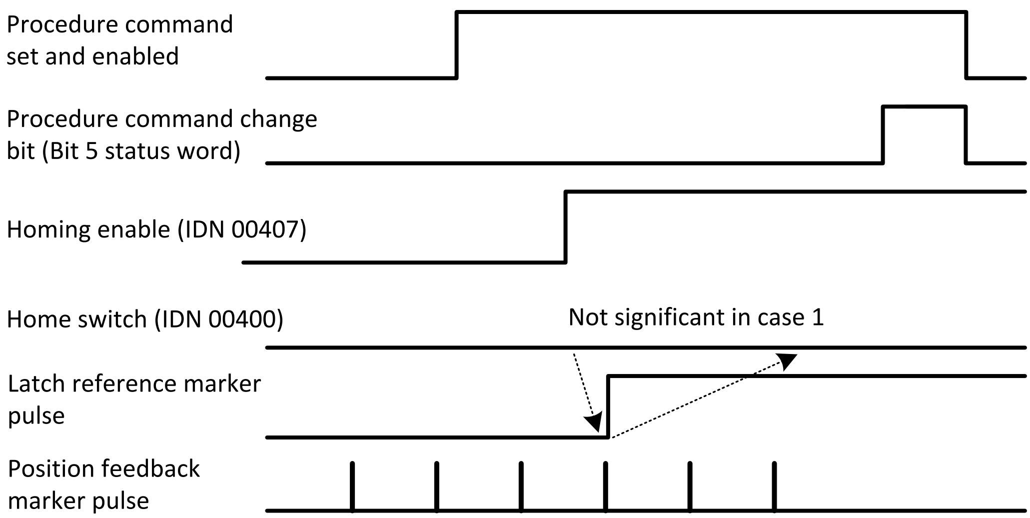


Figure 10-12: CUCH case 1

Case 2.1: the home switch - is connected to the drive, but the control unit makes calculations.

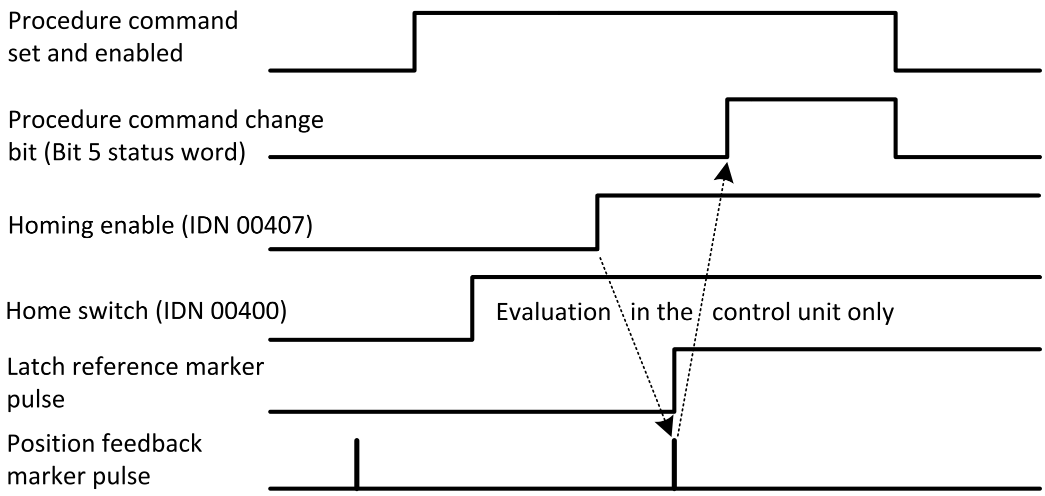


Figure 10-13: CUCH case 2.1

Case 2.2: the home switch is connected to the drive and the drive also makes calculations, but keeps the control unit informed.

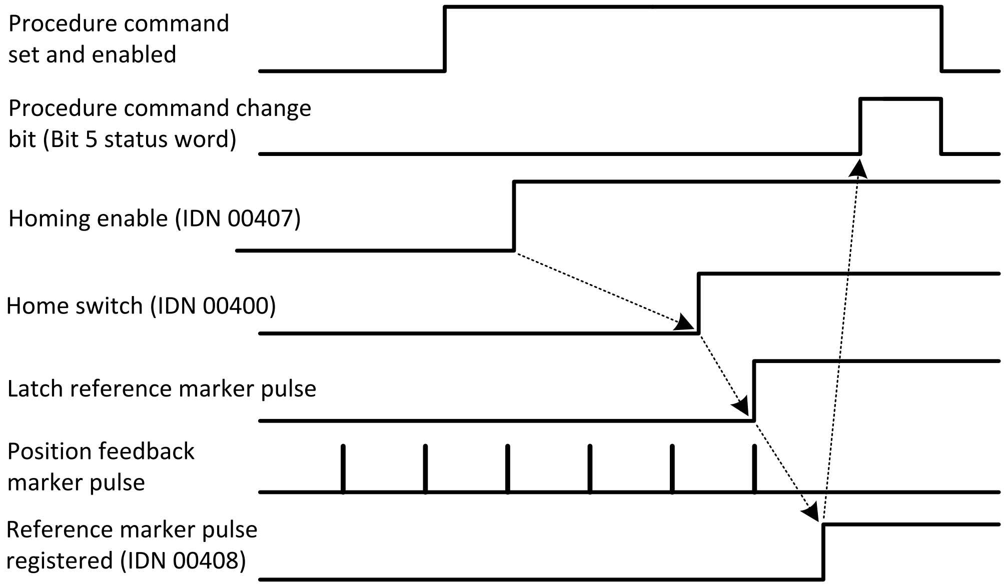


Figure 10-14: CUCH case 2.2

The CUCH function is as follows;

1. Configure reference distance 1 and 2 (S-0-0052/52 and S-0-0054/54), and reference offset 1 and 2 (S-0-0150/150 or S-0-0151/151).[6] These parameters only need to be commissioned once, if the motor or encoder setup has changed. If hardware changes have been made, the values in these parameters may need to be varied.

Warning: Care must be exercised so that all homing related IDN's are suitably configured whenever hardware (e.g. motor or encoder) changes are made, since unexpected behaviour may result.

2. Configure homing parameter (S-0-0147/147) and digital input as index pulse (P-0-0422/33190)
3. Execute CUCH procedure command (S-0-0146/146) by setting its value to 3.
4. The drive resets its actual position to account for calculated offset.
5. At the completion of homing Status Actual Position Value (S-0-0403/403) is set to flag the successful completion of the DCH function and the DCH function (S-0-0146/146) must be reset to 0 by an external entity before the drive will undertake other tasks.

The *calculate displacement procedure command* (S-0-0171/171) and *set reference point procedure command* (S-0-0172/172) must be executed independently.

Drive Controlled Moves

The Drive Controlled Moves (DCM) block allows a set of pre-programmed moves to be stored on the drive. In DCM mode, the drive will control the system based on the move profile defined by a selected DCM. A DCM is defined by:

- Target position – in absolute or relative (set via P-0-268/33036)
- Maximum velocity
- Acceleration
- Deceleration
- End delay time – DCM processing will pause for this period of time at the completion of the move
- Next move – identifies the index of the next move in the DCM sequence. If index value is between 1 and 8 (inclusive), the target position at this index will be executed next. This allows multiple DCMs to be sequenced.

[6] This 'reference offset' does NOT currently get used by the AMD2000, it may do so in future releases.

IDN	Label
P-0-0256 / 33024	DCM Procedure Command
P-0-0257 / 33025	DCM Status Word
P-0-0260 / 33028	DCM Target Position
P-0-0261 / 33029	DCM Maximum Velocity
P-0-0262 / 33030	DCM Acceleration
P-0-0263 / 33031	DCM Deceleration
P-0-0264 / 33032	DCM Delay Time
P-0-0265 / 33033	DCM Next Move
P-0-0266 / 33034	DCM First Move ID

To use DCMs:

- Program set of desired move segments Manage execution of DCM's via the DCM procedure command P-0-0256 / 33024
- Monitor status of DCM via DCM Status Word IDN P-0-0257 / 33025.

Programming DCMs

Five of the above list of DCM related IDN's are arrays of values, and these are the IDN's 33028, -29, -30, -31, -32 and -33. The maximum number of entries for any IDN array in this list is set by the number of supported DCM segments, which for the AMD2000 is up to 8. When programming DCM moves, all six IDN's must be programmed for each desired move segment. To program 5 move segments you must program each of the IDN's with 5 corresponding array elements, where the order of their application in performing a sequence of moves will be determined by the value of IDN 33033, or the "Next Move" specification. If this Next Move IDN is set to 0, then the sequence of moves has ended**.** Therefore each move can be identified by an index of 1 through to N moves. The sequence of moves begins with the move index set in IDN 33034.

In the following example 5 DCM are created to execute the following motion:

1. Move to 100 mm at 1000mm/min
2. Move to 200 mm at 2000mm/min
3. Move to 300 mm at 5000mm/min
4. Move to -100 mm at 10000mm/min
5. Move to 0 mm at 1000mm/min

DCM 1, 2 and 3 are chained together with a 1 second delay at the end of DCM 1 and a 2 second delay at the end of DCM 2. This will result in the following action when DCM 1 is executed:

1. Move to 100mm
2. Pause for 1 second
3. Move to 200mm
4. Pause for 2 seconds
5. Move to 300mm
6. Finish

So the table of moves we are after is,

IDN	Label	Move 1	2	3	4	5
P-0-0260 / 33028	DCM Target Position	100	200	300	-100	0
P-0-0261 / 33029	DCM Maximum Velocity	1000	2000	5000	10000	1000
P-0-0262 / 33030	DCM Acceleration	100	200	300	400	500
P-0-0263 / 33031	DCM Deceleration	500	400	300	200	100
P-0-0264 / 33032	DCM Delay Time	1000	2000	0	0	0
P-0-0265 / 33033	DCM Next Move	2	3	0	0	0

To program this set of move segments, the DCM parameters must be programmed as follows,

P-0-0260 / 33028 = 1000000,2000000,3000000,-1000000,0
Program the DCM target position (units used here are 0.1µm)

P-0-0261 / 33029 = 1000000,2000000,5000000,10000000,1000000
Program desired DCM velocities (units are 1µm/min)

P-0-0262 / 33030 = 100000,200000,300000,400000,500000
Program acceleration rates (units are 1µm/sec^2)

P-0-0263 / 33031 = 500000,400000,300000,200000,100000
Program deceleration rates (units are 1µm/sec^2)

P-0-0264 / 33032 = 1000,2000,0,0,0
Program 1 second (1000msec) delay for DCM 1 and 2 seconds for DCM 2

P-0-0265 / 33033 = 2,3,0,0,0
Chain DCM 1, 2 and 3 together

P-0-0266 / 33034 = 1
Set desirable first move segment ID

DCM Status Word:

Bit	Value	Description
0-1	0	DCM inactive
	1	DCM halted
	3	DCM in progress
2	0	DCM not complete
	1	DCM complete
3	0	No delay active
	1	End of DCM delay is active
4	0	No error
	1	DCM error has occurred
5-15	1-64	Segment ID of the move currently in progress

10.1.20 Modulo Operation

Description

The ‘modulo’ operation is a feature that can be applied only to position feedback. Internally the drive represents variables relating to “joint” motion as distinct from “motor” motion. Motor motions are used in tightly coupled, very fast current control loops that need not concern the end user for most applications, whereas joint motions are reported in scaled values of a more relevant type and magnitude related to movements in position and velocity on the particular machine or automation application.

Modulo operations are almost always applied to rotational axes where one revolution, or a sector of one revolution, results in the ‘joint’ returning to a reference starting position (e.g. one complete revolution of a shaft or gear). The axis position as it is represented internal to the drive can be wrapped upon a specific proportion of a revolution (usually a full revolution). For example, a 500° motion from an initial reference starting point will be shown as 140° if the module operation is configured to “wrap” or “modulo” the motion every 360°.

To enable module operation, set bit 7 of the position scaling parameter IDN (S-0-76/76) to 1. The Modulo parameter (S-0-103/103) must then be set to the value at which “wrapping” occurs. The Modulo operation is applied to the joint position, which means it applies to motions that are measured by the external encoder feedback that are closer to the end effector, tool tip, or driven end of the machine, rather than the motor or driving end. If the gear ratio is not 1:1 then the motor will have done more than (or less than) a full revolution before the joint motion completely covers one full modulo of motion

IDN	Label
S-0-76/76	SoE Position Scaling – Type
S-0-103/103	Modulo Value

10.1.21 Motion Constraints and Limits

Description

In practice most machines, and thereby machine axes, cannot move through an unlimited range of motion. People or machine parts can impede the motion. There may also be fundamental limitations governing rates and accelerations to do with the machining process itself. The AMD2000 provides a number of useful configuration parameters for restraining its controlled axis’ movements.

These can be applied to both the ***command*** and ***feedback*** quantities for position, velocity, acceleration, and force/torque.

- <u>Constraints</u> are applied to ***commands*** (i.e. control demands) so that the axis can never exceed certain settings. If a particular demand exceeds a constraint value, it is merely held at the constraint value, but otherwise no errors or warnings are issued. Constraints come in two flavours, and are both applied if enabled;
    - Global, and
    - Safety related.

- <u>Limits</u> are applied to ***feedback*** variables and used for monitoring axis behaviour. They result in Class 1 Diagnostic (C1D) errors if exceeded.

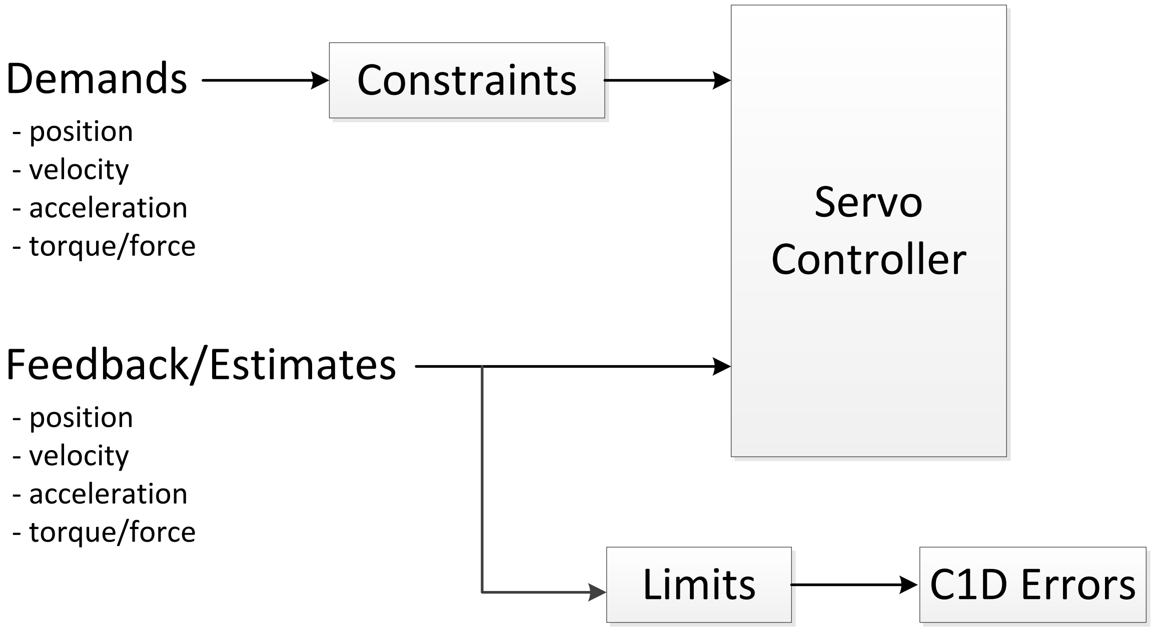


Figure 10-15 Overview of Motion Constraints and Limits

Global Constraints

Global constraints specify the minimum and maximum values associated with demands issued to the servo control loops. In the case where a particular limit is not enabled, its global limit is set to the maximum internally representable value.[7] The full set of adjustable constraints is listed below, and each of these constraints is enabled by setting its associated bit to 1 (ON) in the Global Constraints Enable Flag (P-0-0099 / 32867). The values residing in the following list of IDN's, if so enabled, will be applied to constrain their associated demands;

IDN	Label
P-0-0099 / 32867	Global Constraints Enable Flag
P-0-0100 / 32868	Global Maximum Position Constraint
P-0-0101 / 32869	Global Minimum Position Constraint
P-0-0102 / 32870	Global Maximum Velocity Constraint
P-0-0103 / 32871	Global Minimum Velocity Constraint
P-0-0104 / 32872	Global Acceleration Constraint (positive velocity)
P-0-0105 / 32873	Global Acceleration Constraint (negative velocity)
P-0-0106 / 32874	Global Deceleration Constraint (positive velocity)

[7] The AMD2000 used fixed integer representations internal to the drive, and these make scaling of these variables quite important. Therefore even if the user hasn't specified a constraint, there is always a global constraint due to the size of variable that can be represented.

P-0-0107 / 32875	Global Deceleration Constraint (negative velocity)
P-0-0108 / 32876	Global Maximum Force Constraint
P-0-0109 / 32877	Global Minimum Force Constraint

Each bit of the Global Constraints Enable Flag (IDN P-0-0099) and its associated constraint is listed below;

Bit	Label
0	Position Minimum
1	Velocity Minimum
2	Deceleration (positive velocity)
3	Acceleration (negative velocity)
4	Not used
5	Force/Torque Minimum
6	Not used
7	Not used
8	Position Maximum
9	Velocity Maximum
10	Deceleration (negative velocity)
11	Acceleration (positive velocity)
12	Not used
13	Force/Torque Maximum
14	Not used
15	Not used

4 Least Significant Bits (LSB)

Example of Usage
Figure 10-16 shows an example of configuring the global constraints. The grey region "inside the onion" shows the allowable region of operation.

The parameters settings are for position, velocity and acceleration, BUT not force, so only the 4 LSB and the mid-bits need to be activated. The following is applied:

P-0-0099 = 3855 [binary: 0000 1111 0000 1111 **(<--these last are the 4 LSB)**]
P-0-0100 = 0.4 [m]
P-0-0101 = -0.1 [m]
P-0-0102 = 1200 [mm/min]
P-0-0103 = -900 [mm/min]
P-0-0104 = 0.003 [m/s/s]
P-0-0105 = -0.003 [m/s/s]
P-0-0106 = -0.001 [m/s/s]
P-0-0107 = 0.001 [m/s/s]

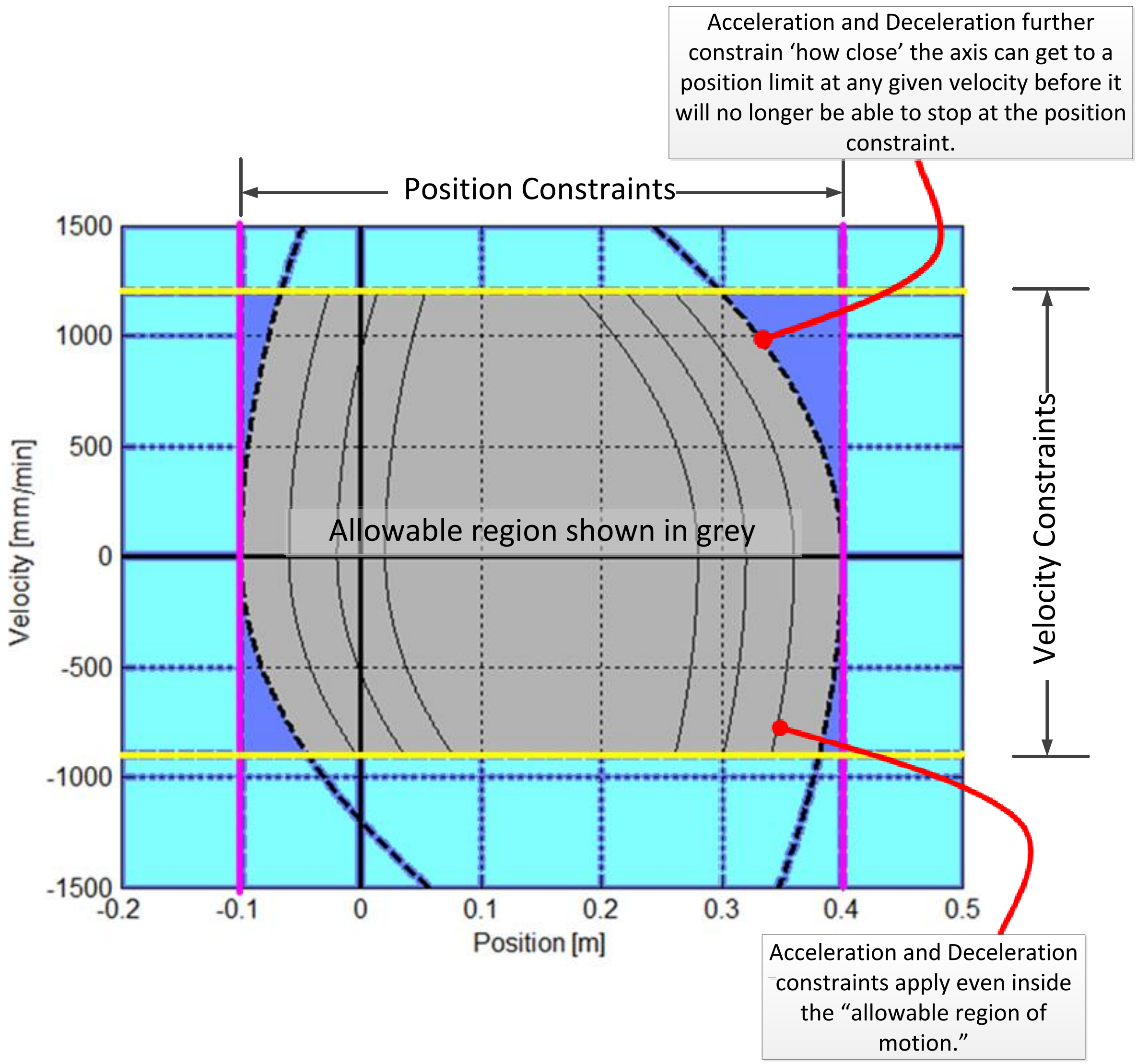


Figure 10-16 Global Constraints Example

Note that the acceleration/deceleration constraints are enforced anywhere within the working envelope (position vs. velocity space), not just those points dictated by the position constraints.

Safety Constraints

Safety constraints are intended to be dynamically enabled and disabled while the drive is operating. Setting the Master Enable IDN P-0-120 / 32882 to the value of 1 will result in the safety constraints being applied. A separate enable flag, IDN P-0-121 / 32883 is used to individually specify which constraint is to be enabled, similar to the global constraints described above. An example application of this feature may be for the master to dynamically implement a conservative set of constraints under potentially dangerous situations, such as when the axis is not homed or the machine door is open. Note that these are NOT CE Safety certifiable safety functions, thus they provide safety related capability for the AMD2000 without the associated claims for reliability.

The full set of adjustable constraints is listed below, and each of these constraints is enabled by setting its associated bit to 1 (ON) in the Safety Constraints Enable Flag (P-0-0099 / 32867). The values residing in the the following list of IDN's then provide the relevant constraint levels;

IDN	Label
P-0-120 / 32882	Safety Constraints Master Enable
P-0-115 / 32883	Safety Constraints Enable Flag
P-0-0116 / 32884	Safety Maximum Position Constraint
P-0-0117 / 32885	Safety Minimum Position Constraint
P-0-0118 / 32886	Safety Maximum Velocity Constraint
P-0-0119 / 32887	Safety Minimum Velocity Constraint
P-0-0120 / 32888	Safety Acceleration Constraint (positive velocity)
P-0-0121 / 32889	Safety Acceleration Constraint (negative velocity)
P-0-0122 / 32890	Safety Deceleration Constraint (positive velocity)
P-0-0123 / 32891	Safety Deceleration Constraint (negative velocity)
P-0-0124 / 32892	Safety Maximum Force Constraint
P-0-0125 / 32893	Safety Minimum Force Constraint

Each bit of the Safety Constraints Enable Flag (IDN P-0-0121) and its associated constraint is listed below;

Bit	Label
0	Position Minimum
1	Velocity Minimum
2	Deceleration (positive velocity)
3	Acceleration (negative velocity)
4	Not used
5	Force Minimum
6	Not used
7	Not used
8	Position Maximum
9	Velocity Maximum
10	Deceleration (negative velocity)
11	Acceleration (positive velocity)
12	Not used
13	Force Maximum
14	Not used
15	Not used

4 Least Significant Bits (LSB)

Error Limits

Error limits are applied similarly to the above constraints, but they influence the performance in an entirely different fashion. Error limits are applied to monitored feedback variables, and so do NOT limit the demands going to the servo controller. They operate via a combination of applied hard and soft limits (see Figure 10-18 and Figure 10-19 and the description below). When error limits are exceeded then C1D errors are asserted to stop the drive from further motor movement.

To enable error limits, the Master Enable (P-0-0126 / 32894) must be set to 1 and individual bits corresponding to desired limits in the Enable Flags (P-0-127 / 32895) must be configured. Refer to the SoE parameter reference document for parameter details. The full set of settable constraints is listed below, and each of these constraints is enabled by setting its associated bit to 1 (ON) in the Safety Constraints Enable Flag (P-0-0099 / 32867). The values residing in the following list of IDN's are relevant to setting Error Limits;

IDN	Label
P-0-0126 / 32894	Error Limits Master Enable
P-0-0127 / 32895	Error Limits Enable Flags
P-0-0128 / 32896	Array for Position Hard Limits [Minimum , Maximum]
P-0-0129 / 32897	Array for Position Soft Limits [Minimum , Maximum]
P-0-0131 / 32899	Rotary Joint with Limited Stroke Enable
P-0-0132 / 32900	Array for Location of End Stops on a Rotary Joint [CCW ,CW]
P-0-0133 / 32901	Array for Velocity Hard Limits [Minimum , Maximum]
P-0-0134 / 32902	Array for Acceleration Hard Limits [For +Velocity , For -Velocity]

Each bit of the Error Limits Enable Flag (IDN P-0-0127) and its associated constraint is listed below;

Bit	Label
0	Position Soft Minimum
1	Position Hard Minimum
2	Position Deadstop Minimum
3	Not used
4	Not used
5	Velocity Hard Minimum
6	Not used
7	Not used
8	Position Soft Maximum
9	Position Hard Maximum
10	Position Deadstop Maximum
11	Not used
12	Not used
13	Velocity Hard Maximum
14	Not used
15	Not used

If the drive is enabled specifically for a Rotary Joint with the Limited Stroke Enable (P-0-0131 / 32899 where 1=ON) then the axis error limits are governed by the rotational limits specified in the Array for Location of End Stops on a Rotary Joint [CCW ,CW] (see P-0-0132 / 32900). Such rotations are constrained to within less than one full revolution (see Figure 10-17).

Application and Consequences of Exceeding Error Limits

If the position is within the soft limit error region (see Figure 10-18), the drive will be unable to command decelerations greater than the drive maximum deceleration to stop the joint at the soft position limit specified; the drive then triggers C1D E304 or E305 and shuts down. The IDN P-0-0134 / 32902 can be used to specify the two maximum decelerations to be applied to either +velocity or –velocity motions, however if either of these elements are set to 0, then the maximum deceleration is defined to be the minimum (in magnitude) of Global Constraints (P-0-0106 / 32874 and P-0-0107 / 32875) or, if active, the Safety Constraints (P-0-0122 / 32890 and P-0-0123 / 32891). See definitions previously given in the Constraints section of this document.

Error Code	Label
E304	Positive Soft Predictive Limit Exceeded
E305	Negative Soft Predictive Limit Exceeded

The hard error limits are a simple position and/or velocity value comparison parameter to the estimated position/velocity feedback. If estimated position exceeds the position hard limit then error C1D E330 or E331 is asserted. Similar velocity violations result in error C1D E332. The hard limits may help to define the boundary between safe and hazardous operation, such as the ends of a linear operating boundary, or the maximum safe velocity.

Error Code	Label
E330	Positive Position Hard Limit Exceeded
E331	Negative Position Hard Limit Exceeded
E332	Positive Velocity Hard Limit Exceeded
E333	Negative Velocity Hard Limit Exceeded

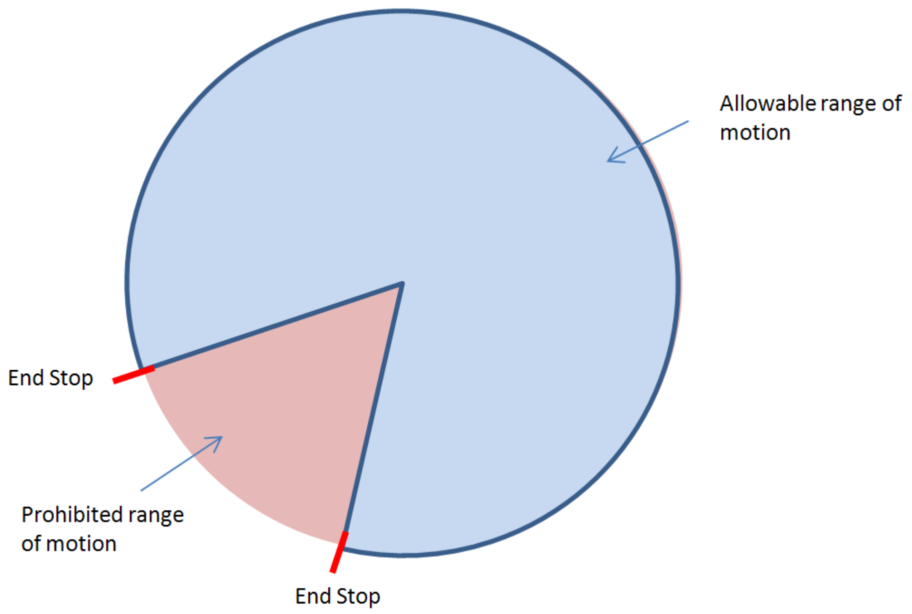


Figure 10-17 Modulo Rotary Axis with Limited Stroke

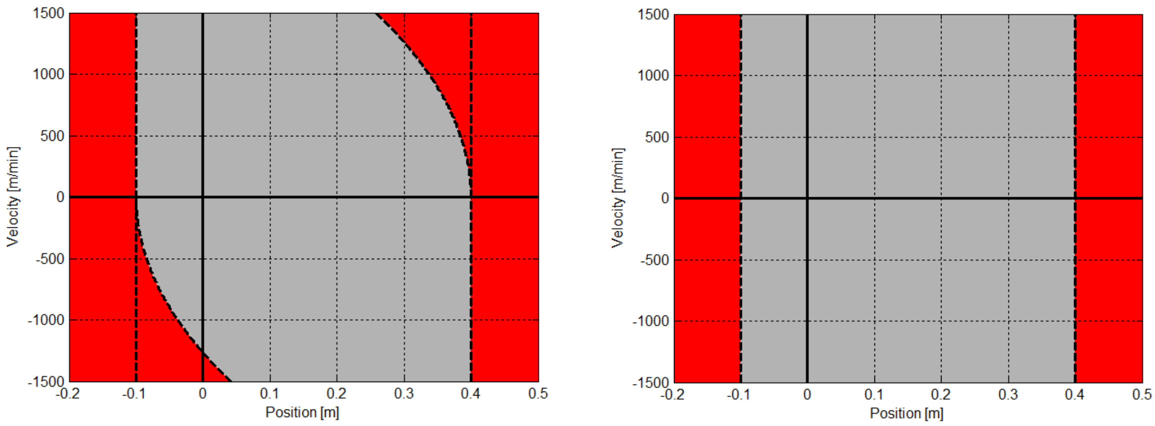


Figure 10-18 Position Soft (left) and Hard (right) Error Limits – IDN P-0-128 = IDN P-0-129 = [-0.1, 0.4] metres

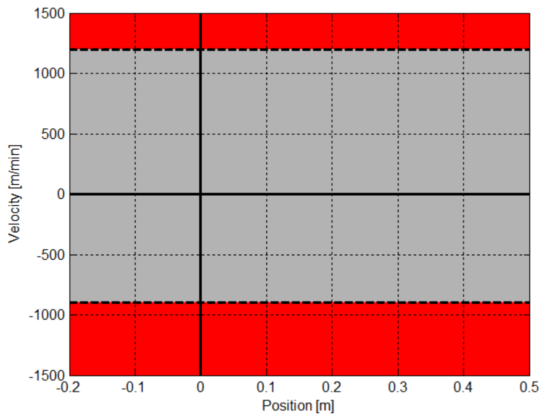


Figure 10-19 Velocity Hard Error Limit – IDN P-0-133 = [-900, 1200] mm/min

Configuring Maximum Velocity

In order to achieve high precision calculations in the drives control system, fixed-point scaling is utilised. However, this puts an upper restriction on the maximum representable velocity. For high speed applications, for example spindle motors, the ability to achieve high speed is more important than precision. In order to be able to manage this trade-off between precision against range, use the velocity scaling shift factor (P-0-0852 / 33620). Each increment of the velocity scaling shift factor doubles the maximum velocity range that can be represented:

Setting of Velocity Scaling Factor (P-0-0852 / 33620)	Maximum Velocity Rotary [RPM] / Linear [m/min]
0	1875
1	3750
2	7500
3	15000
4	30000
5	60000
6	120000

10.1.22 Motor Control

Description

The AMD2000 control loops utilise the architecture for position, velocity and torque/current control displayed by *Figure 10-20*.[8] At ANCA Motion the term Motor Control refers to the current control loop, the torque gain scheduler, and all of the appropriate switches to toggle between a variety of magnetic field alignment methods. A high level view of the Motor Control and its context within the AMD2000 control architecture is displayed in *Figure 10-21*. It is clear from these diagrams that the accuracy of the position and velocity controllers must, in part, be determined by the Motor Control.[9]

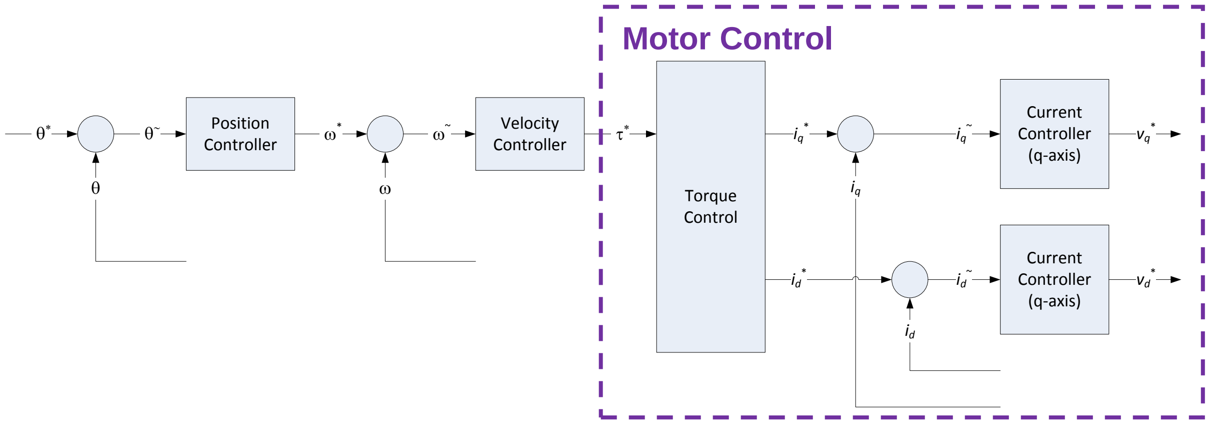


Figure 10-20 Cascaded control architecture found in IEC 61491

As the name is intended to imply, the Motor Control portion of the control loops is intimately related to the type of motor under control. The AMD2000 supports control for two dominant types of motor type;

1. Permanent Magnet Synchronous Motors, or
2. Induction Motors.

ANCA Motion's approach to implementing Motor Control is broken down into a number of sub-systems that must all be configured correctly if they are to be used effectively in controlling either of these two motor types. The two dominant sub-systems of concern to the user are the,

- Torque controller, and the
- Current controller.

Torque and current are intimately related to one another, where the relationship between torque, τ, and q-axis motor current, i_q, is described using a units scaling (or proportional gain) K_t, as follows;

$$\tau = K_t i_q$$

The AMD2000 makes some special assumptions in order to simplify this relationship further. For this drive $K_t = 1$ under all conditions, except for Field Weakening (see below for details). Under this condition the torque and current control commands are the same value.

However, as far as the servo control architecture is concerned, the two physical quantities remain distinct. As a consequence, it is necessary for the user to select the appropriate motor type for both the torque and current controller subsystems separately.

[8] The AMD2000 allows for the SoE profile to be applied to data communications with an external EtherCAT device.
[9] Details for the motivation in having two current controllers, one for "quadrature" and one for "direct" current (so-called q and d currents), is given elsewhere in this user manual under the section title "Field Orientation Initialisation."

Warning: Care must be exercised so that configuration changes to the type of motor under control are made to both the Torque Controller AND the Current Controller subsystems in the Motor Control. Failure to do this can cause unexpected behaviour.

In addition to the flexible configuration of both the Torque and Current Controllers, the following section concerning Motor Control will describe details including the,

- Current loop integral gain scheduler,
- Current/Torque limits, and the
- Sensor offset calibration.

A final portion will be dedicated to the configuration and diagnosis data for thermal protection of the drive and motor, which are important aspects of implementing a successful Motor Control.

The list of relevant IDN's discussed in this section on Motor Control is quite extensive, and is broken down by the relevant sub-section headings as follows;

Torque Control

IDN	Label
S-0-0080 / 80	NC Torque (Force) Setpoint Command
S-0-0081 / 81	Torque Loop Additive Torque Command
P-0-0222 / 32990	Torque Setpoint Switch (Primary)

Field Weakening of PMSM

IDN	Label
P-0-0929 / 33697	Field Weakening Lookup Table – Number of Break Points
P-0-0930 / 33698	Field Weakening Lookup Table – Velocity Break Points
P-0-0931 / 33699	Field Weakening Lookup Table – Field Weakening (d-axis) Current Command Break Points
P-0-0232 / 33000	Current Limit

Induction Motor V/F Control

IDN	Label
P-0-0006 / 32774	Motor poles
P-0-0219 / 32987	VF Control - Minimum Velocity Command
P-0-0220 / 32988	VF Control - Velocity Command Scale Factor
P-0-0215 / 32983	VF Control - Max Current
P-0-0216 / 32984	VF Control - Stop Current
P-0-0217 / 32985	VF Control - Stop Voltage
P-0-0218 / 32986	VF Control - Stop Time
P-0-212 / 32980	VF Curve - Break Points PgmLen
P-0-213 / 32981	VF Curve - Velocity Break Points
P-0-214 / 32982	VF Curve - Voltage Break Points

Current Control Loop

IDN	Label
S-0-106 / 106	Current Control Q Axis Gain
S-0-107 / 107	Current Control Q Axis Integral Time
S-0-119 / 119	Current Control D Axis Gain
S-0-120 / 120	Current Control D Axis Integral Time
P-0-041 / 32809	Enable Absolute Current Feedback
P-0-222 / 32990	Torque Setpoint Switch – Primary Mode

P-0-228 / 32996	Torque Setpoint Switch – Secondary 1 Mode
P-0-503 / 33271	Current Setpoint Switch – Primary Mode
P-0-506 / 33274	Commutation Angle Switch
P-0-507 / 33275	Current Setpoint Switch – Secondary 1 mode
P-0-510 / 33278	Motor Control Tuning Procedure Command

Current Loop Integral Gain Scheduler

IDN	Label
P-0-239 / 33007	Current Control Q axis Low Current Boost Enable
P-0-240 / 33008	Current Control Q axis Low Current Boost Threshold
P-0-241 / 33009	Current Control Q axis Low Current Boost Integral Time

Current and Torque Limits

IDN	Label
S-0-0109 / 109	Motor Peak Current [A]
S-0-0110 / 110	Amplifier Peak Current [A]
P-0-20224 / 32992	Motor Torque Constant (AMD5000 only) [Nm / A]
P-0-0225 / 32993	Variable Torque Control Word
P-0-0226 / 3994	Variable Torque Limit – Maximum [Nm]
P-0-0227 / 32995	Variable Torque Limit – Minimum [Nm]
P-0-0232 / 33000	*q*-axis current limit [A]
P-0-0926 / 33694	*d*-axis current limit [A]
P-0-1242 / 34010	Temperature Monitoring Control Word
P-0-1243 / 34011	Amplifier Temperature Current Limiting – Temp Threshold [degC]
P-0-1244 / 34012	Motor Temperature Current Limiting – Temp Threshold [degC]
P-0-1245 / 34013	Amplifier Temperature Current Limiting – Decay Rate [A / degC]
P-0-1246 / 34014	Motor Temperature Current Limiting – Decay Rate [A / degC]
P-0-1252 / 34020	Power Limit [W]

Current Sensor Offset Calibration

IDN	Label
P-0-032 / 32800	Current Sensor Offset Adaption Rate
P-0-033 / 32801	Current Offset Calibration Time
P-0-034 / 32802	Phase U current sensor offset – EOL calibrated
P-0-035 / 32803	Phase W current sensor offset – EOL calibrated
P-0-040 / 32808	Current Adaption Control Word

I^2T Overload Protection

IDN	Label
S-0-109 / 109	Peak Motor Current
S-0-114 / 114	Motor Load Limit
P-0-282 / 33050	Estimated Current Vector in DQ Axis.
P-0-1248 / 34016	Motor Overload Threshold

I^2R Overload Protection

IDN	Label
S-0-111 / 111	Motor Continuous Current Rating
S-0-112 / 112	Power Stage Continuous Current Rating

P-0-1232 / 34000	Motor Thermal Rise Time
P-0-1233 / 34001	Power Stage Thermal Rise Time
P-0-1234 / 34002	Motor I2R Overload Warn Level
P-0-1235 / 34003	Power Stage I2R Overload Warn Level

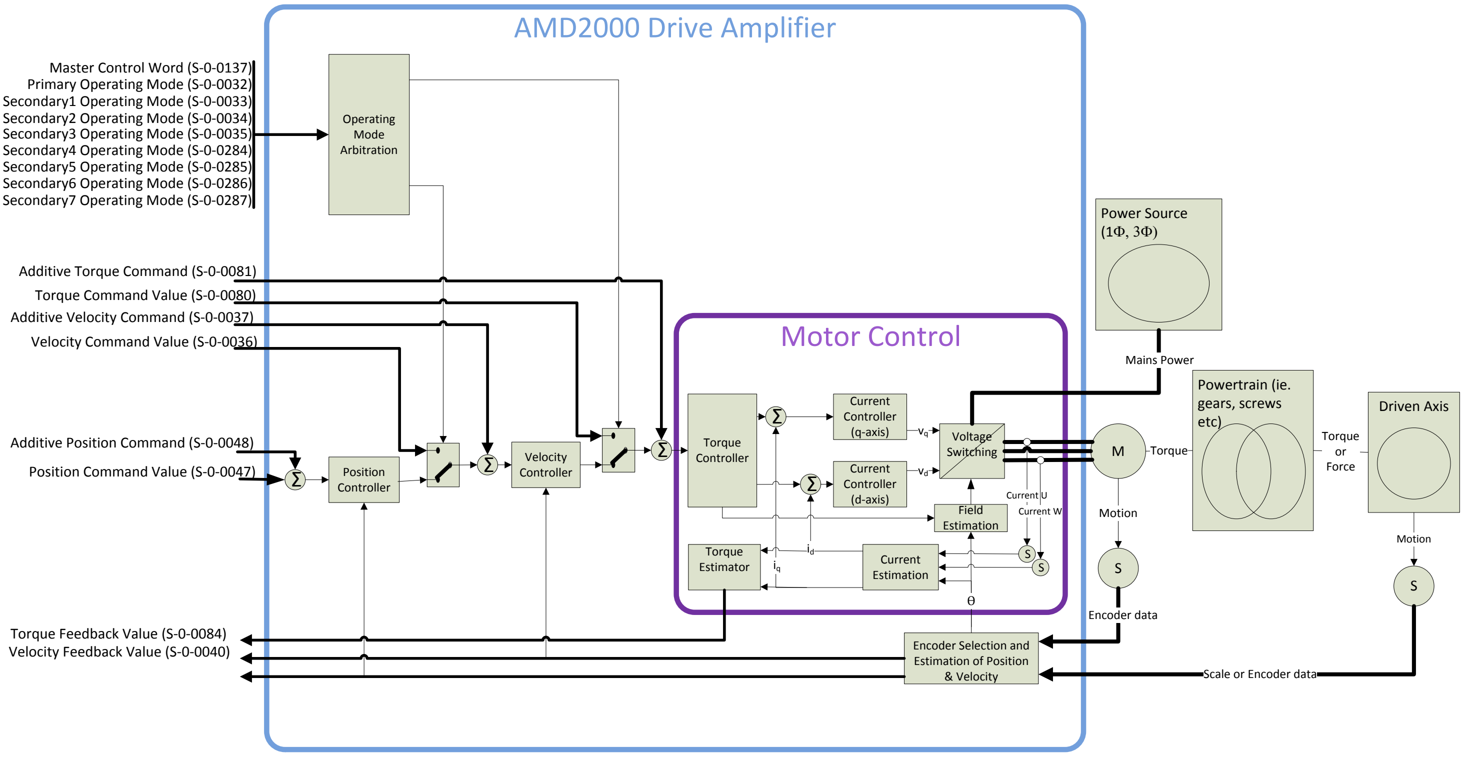


Figure 10-21 Servo controllers in the AMD2000 nested according to IEC 61800-7-2.

Torque and Current Control

As previously mentioned, torque and current commands are virtually synonymous in the AMD2000, except in the special case where Field Weakening may apply to a PMSM type of motor. As a consequence of this, it should be evident from *Figure 10-22* that an external entity may gain access to setting torque commands, and thereby be able to affect current commands. The torque control loop takes either a torque command from the velocity control loop output or an externally originating NC torque command via IDN S-0-0080/80. This command can be further modified by the simple addition of an offset torque using IDN S-0-0081 / 81. Details for how to select whether NC or velocity control is the source of the torque commands is presented elsewhere in this manual under “Operating Modes.” In addition, up to five notch filters and/or one low-pass filter may be applied to the torque command signal, the details of which can be found elsewhere in this manual under the title “Torque Command Filters.”

Configuring Torque and Current Controllers by Motor Type

The current control and torque control techniques for the Primary mode are selected via (P-0-503 / 33271) and (P-0-222 / 32990) respectively. By choosing to fill in these IDN with one of the following two values, the appropriate techniques are selected for application in the Motor Control;

10 = Permanent Magnet Servo Motor (PMSM) control, or
15 = Induction Motor Velocity over Frequency (IM V/F) control.

Similarly, the current control and torque control techniques for the Secondary1 mode can be selected using the same values placed into IDN’s P-0-507 / 33275 and P-0-228 / 32996, respectively.

In addition to the above settings which need to be varied depending on the type of motor being driven, the motor commutation technique must also be selected by filling in IDN P-0-506 / 33274 with the correct value. Once again the user selects from either of the two values given above for the appropriate motor.

And finally, the type of voltage control must be selected by setting IDN P-0-041 / 32809. A value of 0 corresponds to separate (quadrature-direct) current controllers suitable for PMSM Motor control, and a value of 1 in the IDN corresponds to a single current controller suitable for Induction Motor control.
A summary of the above settings for the two different types of supported motor is as follows;

User/external entity must set the...	IDN	Motor Type	
		PMSM	IM V/F
Primary mode of current control	P-0-503 / 33271	10	15
Primary mode of torque control	P-0-222 / 32990	10	15
Technique of motor commutation	P-0-506 / 33274	10	15
Technique of voltage control	P-0-041 / 32809	0	1

If Motor Type =PMSM

When the motor type has been set for PMSM, there are further options that may be chosen. PMSM torque control usually converts torque commands directly to q-axis current command for the current control using $K_t = 1$, as previously described. The exception to this is for higher speeds where the user may wish to alter this simple relationship to account for power limits by using a Field Weakening technique.

Field Weakening

In such cases, the AMD2000 incorporates a Field Weakening technique to command higher velocity from the PMSM at digressively lower torque in order to stay within the motor's maximum power output limits. This technique reduces the allowable limit on q-axis current commands, while increasing the d-axis current command. Below is an example of a typical field weakening curve that might be set by the user. Here, the non-field weakening current limit is set to 50A (P-0-0232 / 33000). At 5000RPM field weakening begins, and the user needs to define the Field Weakening Current Command profile (P-0-0929 / 33697, P-0-0930 / 33698, P-0-0931 / 33699). The drive will then calculate the Torque Producing Current Limit internally so as not to violate the overall current limit (P-0-0232 / 33000).

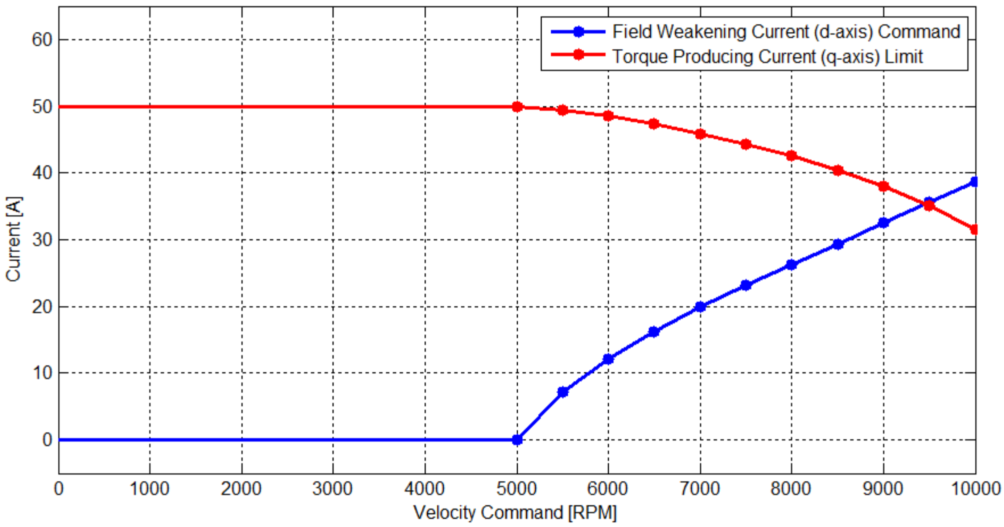


Figure 10-22 Example of Field Weakening

Number of break points (up to 12):
P-0-0929 = 11
Velocity break points [RPM]:
P-0-0930 = [5000, 5500, 6000, 6500, 7000, 7500, 8000, 8500, 9000, 9500, 10000]
Field Weakening (d-axis) Current Command break points [mA]:
P-0-0931 = [0, 7125, 12068, 16159, 20000, 23125, 26250, 29375, 32500, 35625, 38750]

If Motor Type =IM V/F

When the user has selected to pair the drive with an induction motor, there are other options available for the motor control. The AMD2000 gives the user the ability to control the speed of induction motors using Voltage over Frequency (V/F). V/F control switches ON when the velocity command from either the position control loop or an externally originating NC velocity command via IDN S-0-0036 / 36 exceeds the minimum speed threshold defined via IDN P-0-0219 / 32987.

> **Warning:** It is NOT recommended practice for Induction Motor V/F Control to be driven from the position control loop, as difficulties with low speed control using this technique may cause undesirable or unexpected motions.

When V/F control is turned on, VF control – max current (P-0-0215 / 32983) is issued as the current command; if the velocity command drops below the minimum (P-0-0219 / 32987) then braking is executed with the stop current (P-0-0216 / 32984) and stop voltage (P-0-0217 / 32985) for the duration of the stop time (P-0-0218 / 32986).

The V/F curve is produced as a look-up table with inputs specifying the number of break points (P-0-212/32980) and corresponding velocity and voltage break points (P-0-213/32981, P-0-214/32982).

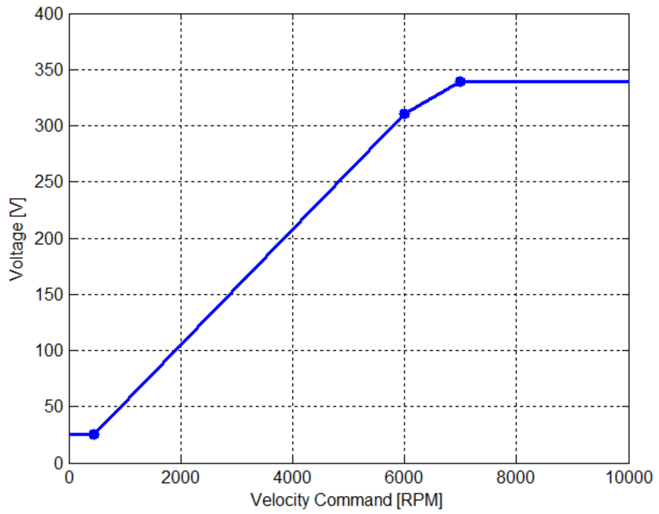


Figure 10-23 Voltage / Frequency Curve Example

Number of break points (up to 5):
P-0-0212 = 3
Velocity break points [RPM]:
P-0-0213 = [450, 6000, 7000]
Voltage limit break points [V]:
P-0-0214 = [25, 294, 339]

Applying Current Control Loop Parameters (for PMSM or IM V/F)

Tuning parameters for the current control loops may be configured at any time; however such configuration is not applied until either the drive re-enable is carried out (see “Operation Modes” elsewhere in this manual) or manually triggered by the user. To manually trigger a current control loop re-tune[10], the user may execute the Motor Control Tuning Procedure Command (P-0-510 / 33278) by changing its default value from 0 to 3 (essentially setting its two least significant bits to 11 from their default setting which is 00). Doing this ‘execution’ will also re-tune the torque control loop.[11] The user should note that the drive software looks for a rising edge change in P-0-510 / 33278 from 0 to 3, so it may be useful to check that the parameter is set to 0 prior to making the change to 3 for execution or the retuning may not occur.

[10] A “re-tune” is an internally executed recalibration and calculation of the necessary control variables for efficient execution of the desired control behaviour. It does NOT mean the drive changes any variables or gains in the control loops as set by the user.
[11] Note that a similar execution command exists for the position and velocity control loops, called the Servo Control Tuning Procedure Command (P-0-187 / 32955). The user should be made aware that if the Servo Control Tuning Procedure Command is executed, it ALSO re-tunes the current and torque control loops at the same time.

Current loop integral gain scheduler

A current loop integral gain scheduler is provided in the AMD2000 to allow increased controller gain during periods of small current command, where the gain characteristic decays drastically as signal frequency increases.

The current loop integral gain scheduler is enabled by setting IDN P-0-239 / 33007 to a value of 1. The parameter P-0-241 / 33009 specifies the current loop integral time constant that will be used at zero current command in place of the normal *q*-axis integral time (S-0-107 / 107). A smaller time constant results in a larger gain, and vice-versa. The resulting gain is then interpolated as a function that adjusts the gain linearly when the current hovers between the symmetric +/- values of the variable described as the “integral gain boost threshold,” specified in IDN P-0-240 / 33008. See *Figure 10-24* for a graphical representation of the function. Note that the resulting scheduler does not have to result in an increased gain near zero current, it could be just as easily configured to decrease the gain near zero current; however, in most normal applications the desire will be to increase the integral gain in such a circumstance.

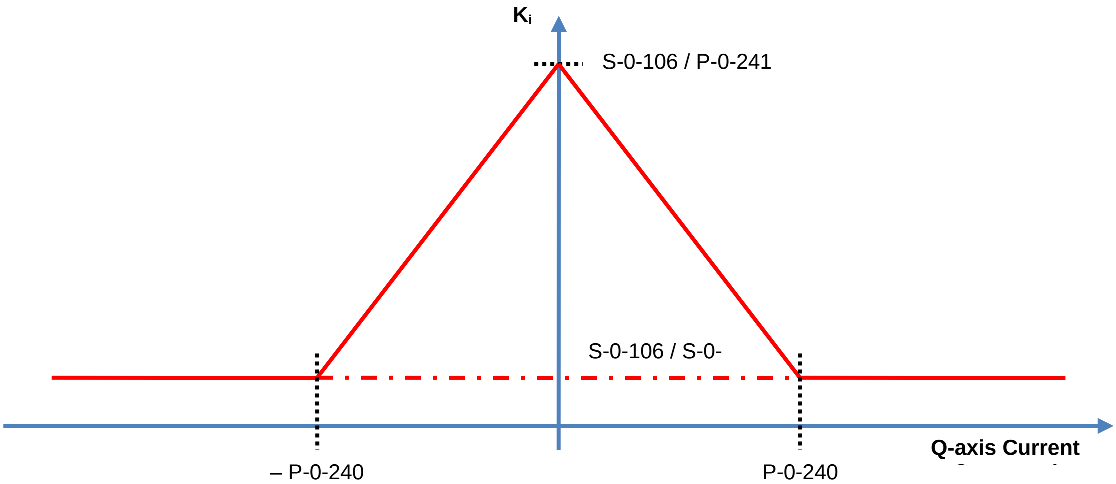


Figure 10-24 Integral Gain Boost

Setting the Current and Torque limits

The minimum magnitude of **all** the current limits defined below will be applied by the motor control. With the exception of the Variable Torque Limit , all the parameters listed below apply current limits on both positive and negative current demands with the exception of the “Amplifier instantaneous current limit” which is applied to detect current over limit and flag an error. The list of limits applied by the motor control, to either current or torque demands, are:

- Motor Peak Current (S-0-0109 / 109) defines the maximum **quadrature** current to which the drive is rated.
- Amplifier Peak Current (S-0-0110 / 110) specifies the maximum **quadrature** current rating of the drive. This variable is configured automatically by the drive, and the user cannot change it.
- Peak Torque Producing Current (P-0-0232 / 33000) defines the maximum **quadrature** current (and by extension torque) which is suitable for the application. It’s intent is to allow the user to specify a torque (or force) limit on couplings or other mechanical features of the application that may be important, but different, to the above motor and drive current limits. Although strictly speaking this limits current, it is intended to apply to mechanical torques (or forces).[12]
- Peak Field Weakening Current (P-0-0926 / 33694) defines the maximum **direct** current which can be commanded for field weakening. This is typically set to zero (0), and should not concern most users.
- Variable Torque Control is a feature which allows the torque applied to the drive to be varied. This is different to the limits defined above, in that different limits can be defined for positive and negative torque. This feature is controlled via the Variable Torque Control Word (P-0-0225 / 32993), where bit0 enables (ie. enable = 1) the Maximum Variable Torque Limit (P-0-0226 / 32994) and bit1 enables the Minimum Variable Torque Limit (P-0-0227 / 32995).

[12] Note that SoE treats the basic units for specifying current and torque quite separately, so the user needs to be aware that current and torque may not simply be value equivalent, even if Kt=1. For example, torque may be represented in basic units of 0.01 N or N/m whereas current is in A. If this is the situation, then with Kt=1, a value of 100 reported for torque over SoE would represent a value of 1 for quadrature current since the torque is being represented in units of cN/m or equivalently N/hm.

- Amplifier Temperature Current Limiting can be configured to adaptively reduce the current limit in response to a rising drive amplifier temperature. This feature enables the drive to continue operating in a reduced capacity as temperature increases as measured by its own internal sensors. This is achieved using the Temperature Monitoring Control Word (P-0-1242 / 34010) by setting bit0 to enable (ie. enable = 1) the amplifier temperature. Next, enable temperature based current limiting using the Temperature Monitoring Control Word (P-0-1242 / 34010) by setting bit8 to enable limiting for the amplifier. Details concerning the specification of the current limits are given below.
- Motor Temperature Current Limiting can be similarly configured to adaptively reduce the current limit in response to a rising motor temperature. This feature enables the drive to continue operating in a reduced capacity as the motor temperature sensor measures temperature increases. This is achieved using the Temperature Monitoring Control Word (P-0-1242 / 34010) by setting bit1 to enable (ie. enable = 1) the motor temperature monitoring. Next, enable temperature based current limiting using the Temperature Monitoring Control Word (P-0-1242 / 34010) by setting bit9 to enable limiting for the motor. Details concerning the specification of the current limits are given below.
- Power Limiting enables the drive to restrict the amount of power which the motor will produce. This is achieved by imposing a limit on the magnitude of the motor current, given the instantaneous value of the voltage being applied to the motor. If IDN P-0-1252 / 34020 is set to a non-zero value, this value is used to set the power, in units of [W], that the motor is restricted to operate within. If this IDN is set to zero then Power Limiting is disabled.
- The drive Amplifier Continuous Current Limit can be set to detect current overlimits in the sensed **phase currents** (Iu, Iv, Iw) and flag an error in response.

Error Code	Label
E308	Continuous Current Limit Exceeded

Variable Torque Control

Variable Torque Control is a feature which allows the applied motor torque to be independently varied in the “positive” and “negative” direction.

Figure 10-25 below shows how different configurations of the Variable Torque Control Word influence the actual torque limits that are applied. For the purpose of discussion, we define a Unified Torque Limit as the smallest current limit that is found from comparing all current limits current configured in the drive (from the above list). This includes the special case of the Peak Torque Producing Current which is actually representing a torque (or force).

Some examples of torque/current limit configurations are:

Case 1: Variable Torque Limits disabled. Unified Torque Limit is applied.
Case 2: Maximum Variable Torque Limit enabled. Unified Torque Limit used for minimum limit.
Case 3: Minimum Variable Torque Limit enabled. Unified Torque Limit used for maximum limit.
Case 4: Maximum and Minimum Variable Torque Limits enabled.
Case 5: Minimum Variable Torque Limit enabled. Minimum limit set to a value larger than zero, which means the drive will be unable to produce zero torque. This configuration is useful for axes which have a non-zero static load applied to them, for example a vertical axis subject to gravity.
Case 6: Maximum Variable Torque Limit enabled. Maximum limit is set to a value which is larger than the Unified Torque Limit; hence the Unified Torque Limit is used.

Note that the minimum limit need not necessarily be negative and the maximum limit need not necessarily be positive, as highlighted in Case 5. However the maximum limit must be larger than the minimum limit, otherwise the drive will report a Class 1 Diagnostic (C1D) error E080.

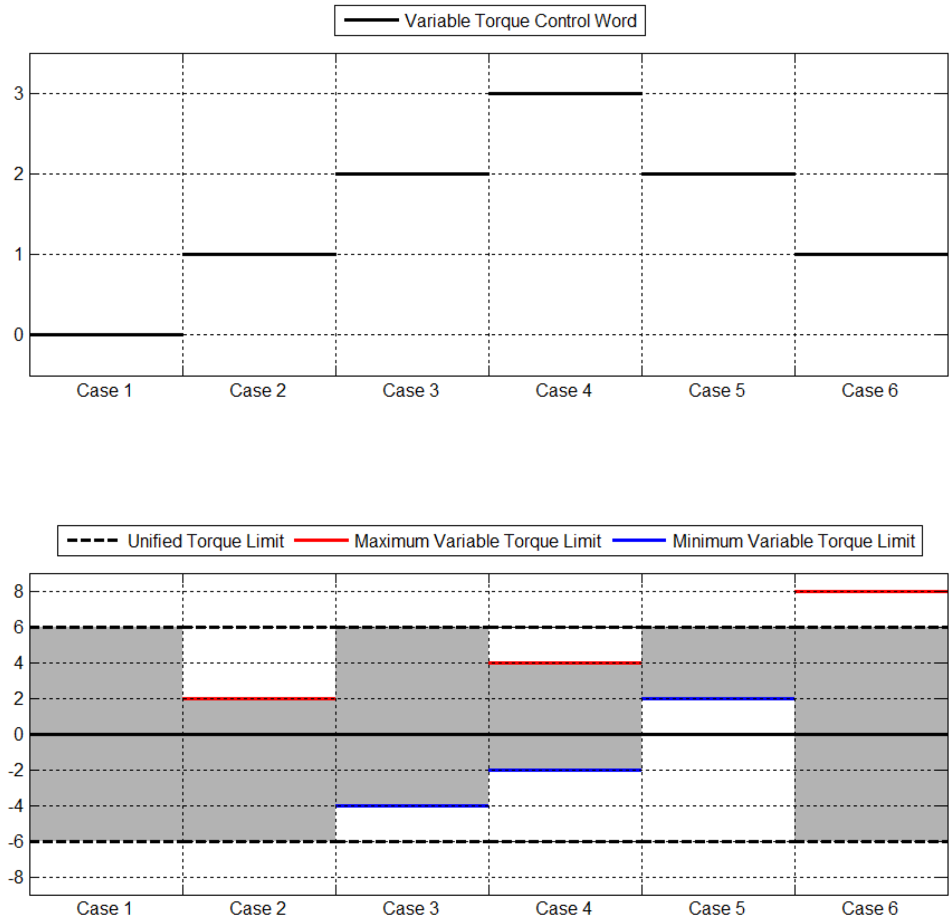


Figure 10-25 Variable Torque Control

Specifying Amplifier / Motor Temperature Current Limits

The first thing that needs to be done to enable temperature based current limiting is to enable temperature monitoring as described above.

Then for each of amplifier and motor there are two variables to define the imposed current limit. They are: Temperature Threshold (amplifier: P-0-1243 / 34011, motor: P-0-1244 / 34012) and Decay Rate (amplifier: P-0-1245 / 34013, motor: P-0-1246 / 34014). The Temperature Threshold [deg C] defines the temperature at which the current limit reduces to zero. The Decay Rate [A / deg C] defines how quickly the current limit approaches the Temperature Threshold as temperature increases. *Figure 10-26* illustrates example configurations for Amplifier / Motor Temperature Based Current Limiting. In this example:

P-0-1243 / 34011 = 60
P-0-1244 / 34012 = 50
P-0-1245 / 34013 = 5
P-0-1246 / 34014 = 2

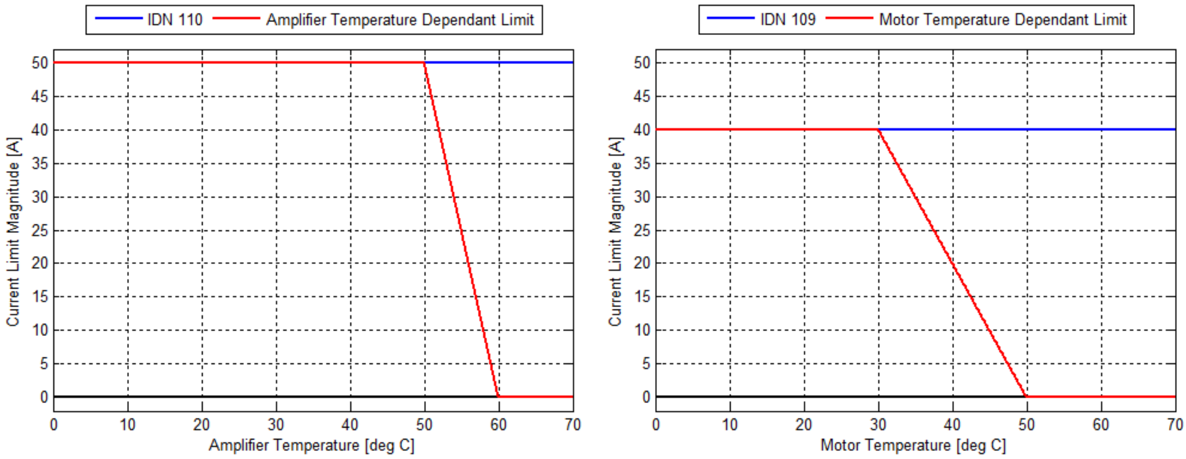


Figure 10-26 Amplifier / Motor Temperature Based Current Limiting

10.1.23 Operating Modes

Description

The AMD2000 supports the SoE profile for Numerical Control (NC) of a drive. The profile allows for the pre-setting of up to 8 operation modes for the drive. Each of these 8 modes, or 'mode slots', can be configured for a particular drive mode of operation (e.g. position control).
The AMD2000 supports up to 4 possible drive modes of operation to assign to any, or all, of these 8 available 'mode slots', namely:

- The position control drive mode, and this can be split into either motor or external encoder feedback modes,
- The velocity control drive mode,
- The torque control drive mode, and
- The mode of "no selected drive mode of operation."

The preceding 4 particular "drive modes of operation" can be pre-assigned by value to each 'mode slot' in the profile (see specific details below). When the drive is in operation, the user or external entity can then select into which mode they wish to place the drive by setting 3 bits in the Master Control Word to select from the 8 operation modes or 'slots'. These bits select which 'mode slot' the drive must query for determining its current "drive mode of operation," thus allowing it to quickly transition from one form of position control to another, or from velocity to torque control, etc. Note that this can be done "on the fly" while the drive is enabled and even moving, and usually within one scan at the default 4 ms scan rate. Transitions in mode while in motion are not generally recommended.

Warning: Switching between operating modes ('mode slots') while in motion should ONLY be done with care, as unexpected motions can result.

In addition to the drive modes of operation being assigned, it is also possible to pre-assign the source of control set point data to be used for each 'mode slot'. Up to three different sources of data are available, including NC input, analog input, or encoder input from the appropriate encoder channel. Details concerning the entire setup follow below, with a table of all the IDN's available for configuration listed immediately below.

IDN	Label
S-0-0134 / 134	Master Control Word
S-0-0135 / 135	Drive Status Word
S-0-0032 / 32	Primary Operation Mode
S-0-0033 / 33	Secondary Operation Mode 1
S-0-0034 / 34	Secondary Operation Mode 2
S-0-0035 / 35	Secondary Operation Mode 3
S-0-0284 / 284	Secondary Operation Mode 4
S-0-0285 / 285	Secondary Operation Mode 5
S-0-0286 / 286	Secondary Operation Mode 6
S-0-0287 / 287	Secondary Operation Mode 7
P-0-0531 / 33299	NC Command Source
S-0-0043 / 43	Velocity polarity configuration
S-0-0055 / 55	Position polarity configuration
S-0-0085 / 85	Torque polarity configuration

Pre-assigning "drive modes of operation"

Each 'mode slot' of the drive can be assigned a value determining its associated drive mode of operation. The primary operation mode IDN (IDN S-0-0032 / 32) and 7 secondary operation mode IDN's (IDN's S-0-0033 / 33 → S-0-0035 / 35 and IDN's S-0-0284 / 284 → S-0-0287 / 287) can be filled with one of the following four values;

0: No mode of operation,
1: Torque control,
2: Velocity control,
3: Position control using feedback 1 (motor encoder), and

4: Position control using feedback 2 (external encoder).

The list of operating modes supported by the drive can also be accessed via IDN S-0-0292 / 292 (List of Supported Operation Modes).

Pre-assigning "setpoint sources"

Each 'mode slot' of the drive can be assigned a value for its associated setpoint source, which is the data supplied to the controller for subsequent servo-control tracking. NC Command Source (P-0-0531 / 33299) is an IDN array of 8 elements, one for each of the 8 'mode slots.' The correspondence is in ascending order, so the first array element corresponds with the primary operation mode, the second element with the 1st of the 7 secondary operation modes, and so on. Each element can be filled with one of the following 3 values depending on which is the most appropriate source for setpoint information for the corresponding 'mode slot';

0: NC setpoints, available over EtherCAT communications,
1: Analog setpoints, available from analog inputs, or
2: Encoder input setpoints, from the appropriate encoder.

Master Control Word

Bits 11, 9 and 8 of the IDN S-0-0134 / 134 Master Control Word determine which of the operation modes is active. To operate the drive, Bit 15, 14, and 13 must all be set to 1, and this is usually undertaken as part of the start-up and enable sequence in the drive.

Bit 15	: Drive on/off 0 drive off 1 drive on
Bit 14	: Enable drive 0 not enabled 1 enabled
Bit 13	: Halt/restart drive Halt drive when changing from 1 to 0, restart drive when changing from 0 to 1
Bit 12	: Reserved
Bit 11, 9-8	: Operation mode 000 Primary Operation Mode 001 Secondary Operation Mode 1 010 Secondary Operation Mode 2 011 Secondary Operation Mode 3 100 Secondary Operation Mode 4 101 Secondary Operation Mode 5 110 Secondary Operation Mode 6 111 Secondary Operation Mode 7
Bit 10	: Control unit synchronization bit
Bit 7 - 0	: Reserved

The technical data pack accompanying the AMD2000, or the appropriate online resources for the same, should include the "Digital Servo Drive SoE Parameter Reference" (dd_reference_SoE_parameter.pdf**)** contains details concerning setting other bits in the Master Control Word.

Drive Status Word

Bits 10, 9 and 8 of the IDN S-0-0135 / 135 Drive Status Word reflect the currently active operation mode or 'mode slot' being used by the drive. This can be queried by external systems to assess the current operation mode of the drive.

10.1.24 Temperature Monitoring

Description

This document outlines how the drive can be configured to use temperature sensors that are located physically in the motor (if applicable) and the amplifier (drive power stage). Temperature monitoring is essential in machine operation, as excessive heat can damage components.

Enabling temperature monitoring

The user can select what temperature units (0.1^{o} C or 0.1^{O} F) to work with via IDN S-0-0208/208, where setting bit 0 of this IDN to a value of 1 results in Fahrenheit, as opposed to a value of 0 which will work with Celsius. IDN P-0-1242/34010 is the control word used to enable/disable temperature monitoring. For more details regarding the specific bits of these parameters, refer to the Digital Servo Drive SoE Parameter Reference manual ("dd_reference_SoE_parameter.pdf") supplied with the drive, or located in our online resources. IDN's 34008 and 34009 are used to report the motor and amplifier (this drive) temperatures as sensed.

IDN	Label
S-0-0208 / 208	Temperature Scaling Type
P-0-1242 / 34010	Temperature Monitor Control Word
P-0-1240 / 34008	Motor Temperature
P-0-1241 / 34009	Amplifier Temperature

Temperature warning / error threshold

If the sensed temperature feedback exceeds a value specified in IDN S-0-0200/200 for the drive amplifier, or S-0-0201/201 for the motor. Should the temperature exceed the shut-down temperature S-0-0203/203 for the drive amplifier, or S-0-0204/204 for the motor, then drive will disable itself and display the C1D diagnostic error message E0104 / E0114 **.** This error must be manually reset prior to the drive being re-enabled.

IDN	Label
S-0-200 / 200	Amplifier warning temperature
S-0-0203 / 203	Amplifier shut-down temperature
P-0-1241 / 34009	Sensed Amplifier Temperature
S-0-201 / 201	Motor warning temperature
S-0-204 / 204	Motor shut-down temperature
P-0-1240 / 34008	Sensed Motor Temperature

Error Code	Label
E0101	Amplifier Temperature Sensor Error - High
E0102	**Amplifier Temperature Sensor Error – Low**
W0103	Amplifier Temperature High Warning
E0104	Amplifier Temperature High Error
E0111	Motor Temperature Sensor Error – High
E0112	**Motor Temperature Sensor Error – Low**
W0113	Motor Temperature High Warning
E0114	Motor Temperature High Error

Enabling additional "PWM-On" temperature threshold

This feature has been used in specific applications where the temperature level is acceptable to enable the drive's controller, but not to enable the drive's power module. Again, IDN P-0-1242/34010 has specific bits that need to be set in order to enable the "PWM-On" temperature threshold detection features, refer to the Digital Servo Drive SoE Parameter Reference manual ("dd_reference_SoE_parameter.pdf") for details. The value in P-0-1237 / P-0-1236 is generally lower than that of S-0-0203 / S-0-0204 (see above), and one example of this

feature's application may be to utilise this error to indicate that an external cooling system needs to be enabled to lower the temperature prior to the drive enabling the power module. The temperature limits for the PWM-On thresholds are set for both the drive amplifier and the motor as shown in the table below. Whereas the temperature thresholds of IDN 203 and 204 are always applied when the drive is enabled, the PWM-On thresholds of IDN 34005 and 34004 are only being evaluated for error conditions when the power module is active (ie. "PWM On").

IDN	Label
P-0-1237 / 34005	Amplifier shut-down temperature with PWM On
P-0-1236 / 34004	Motor shut-down temperature with PWM On

Error Code	Label
E0105	Amplifier Temperature High Error with PWM On
E0115	Motor Temperature High Error with PWM On

Amplifier fan activation (AMD 2000 only)

The following parameters are used to specify threshold values at which the cooling fan will turn on/off.

IDN	Description
P-0-1238 / 34006	Cooling Fan Activation Amplifier Temperature Enable Threshold
P-0-1239 / 34007	Cooling Fan Activation Amplifier Temperature Disable Threshold

Temperature-based current limiting

Temperature rise is often a direct consequence of high motor current; therefore limiting current commands at high temperature reduces the rate of temperature rise and provides continued operating at reduced performance. This feature should not be used in high precision applications.
Current is reduced to zero at specified temperature thresholds of P-0-1243/34011 (drive amplifier) and P-0-1244/34012 (motor).

The upper limit of current given a sensed temperature can be calculated by

$$I_{limit} = (Temp_{zero\ current} - Temp_{sensed}) \times Current\ decay\ rate$$

IDN	Description
P-0-1243 / 34011	Zero Current - Amplifier Temperature Threshold
P-0-1245 / 34013	Current Decay Rate - Amplifier Temperature
P-0-1244 / 34012	Zero Current - Motor Temperature Threshold
P-0-1246 / 34014	Current Decay Rate - Motor Temperature

10.1.25 Torque Command Filters

Description

This document outlines the usage of torque command low-pass and notch filters applicable to the AMD2000 drive. These filters are used to remove unwanted high frequency signals or defined frequency bands (such as regions of mechanical resonance) in the torque used to drive the machine. Removal of resonant frequency bands is often desirable to reduce machine noise and vibration, improving lifespan by reducing fatigue or improving quality in finished products from the machine. The drive can be configured for up to 1 low-pass and 5 notch filters. Only a corner frequency parameter need be set by the user for the low-pass filter, whereas the notch filters require a centre frequency and a Q factor. The relevant IDN’s that need setting by the user are listed as follows;

IDN	Description
P-0-0012 / 32780	Torque Cmd Low Pass Filter Freq
P-0-0013 / 32781	Torque Cmd Notch 1 Filter Freq
P-0-0014 / 32782	Torque Cmd Notch 1 QFactor
P-0-0015 / 32783	Torque Cmd Notch 2 Filter Freq
P-0-0016 / 32784	Torque Cmd Notch 2 QFactor
P-0-0017 / 32785	Torque Cmd Notch 3 Filter Freq
P-0-0018 / 32786	Torque Cmd Notch 3 QFactor
P-0-0019 / 32787	Torque Cmd Notch 4 Filter Freq
P-0-0020 / 32788	Torque Cmd Notch 4 QFactor
P-0-0021 / 32789	Torque Cmd Notch 5 Filter Freq
P-0-0022 / 32790	Torque Cmd Notch 5 QFactor
P-0-0510 / 33278	Motor Control Tuning Procedure Command

The parameters in the above IDN’s can be calculated or estimated as follows,

Low-pass filter corner frequency – signals above this base frequency will be attenuated by more than -3 dB,

Notch filter centre frequency, f_0 – centre frequency of the band needing to be attenuated with the notch, and

Q factor – dimension-less parameter which characterises a resonator’s bandwidth relative to its centre frequency. Q factor is determined from centre frequency f_0 and filter bandwidth f_Δ by the relationship,

$$Q = \frac{f_0}{f_\Delta}, and\ f_\Delta = f_{high} - f_{low}$$

And the recommended procedure for setting the filter configuration is,

1. Set the associated filter frequency parameter to 1 (ON), or 0 (OFF).
2. Set the above configuration parameters and power cycle the drive. To update without a power cycle, use the procedure command P-0-0510/33278 Motor Control Tuning Procedure Command by toggling from 0 to 3.

For parameter details such as data type or scaling, refer to the Digital Servo Drive SoE Parameter Reference manual (“dd_reference_SoE_parameter.pdf”) supplied with the drive, or located in our online resources.

11. Fault Tracing

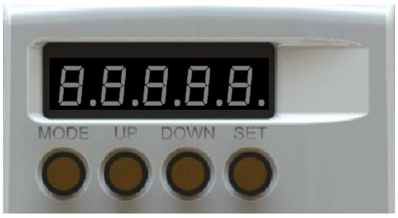
11.1 What this Chapter Contains

This chapter contains information related to the ANCA MotionBench that will guide the user in trouble shooting AMD2000 Series Servo Drive:

- Diagnostic Indicators on the drive
- Communications Status
- Base Firmware Error Codes and Possible Causes
- Firmware Upgrade Errors

11.2 Problem Diagnosis

11.2.11 AMD2000 Indicators



The 7 segment LED display on the AMD2000 serves three functions. It is used to report errors, to indicate the state of the EtherCAT communications and to indicate the state of the drive.

The dots represent wire saving encoder UVW sensor feedback state on power up.

11.2.11.1 Error state

In an error condition, the display will read either **E-###** where **###** refers to the relevant error code. See *11.3 Supported Error Codes* for the description and cause of each.

When no error has been reported, the display will provide information on both the drive state and the communications state.

11.2.11.2 Communications state

To indicate the state of the EtherCAT communications, the leftmost digits of the display will read **C#**, where # refers to the current communications condition as shown in the following table:

C#	Communications State
C0	None
C1	Initialization
C2	Pre-operational
C4	Safe-operational
C8	Operational

11.2.11.3 Drive state

To indicate the state of the drive, the rightmost digits of the display will read d#, where # refers to the current drive condition as shown in the following table:

d#	Drive State
d0	Off
d2	Ready to operate
d3	Enabling
d4	Enabled

11.3 Supported Error Codes

Error codes are displayed on the seven segment display in the format of a prefix followed by a number

11.3.11 Error Code Prefixes

Prefix	Severity	Description
E	Error	Critical faults which disables the drive. (Class 1 Diagnostics).
W	Warning	Tolerable faults, often a monitored measurable parameter has exceeded its specified desirable operating range. (Class 2 Diagnostics).
I	Information	Reported information regarding various internal states of the drives for troubleshooting purposes. (Class 3 Diagnostics).

Only prefix E will be displayed on a AMD2000 Series Servo Drive and prefixes W and I are visible to a CNC.

11.3.12 Error / Warning Codes

A quick summary of the error codes are attached. Please note that Error codes are firmware dependent. A complete and up-to-date error listing will be delivered together with the firmware.

Code	Severity	Label
E0007	Error	Current Offset Adapt Error
E0015	Error	Encoder Amplitude Low - Motor
E0016	Error	Encoder Amplitude High - Motor
E0023	Error	Excess Servo Position Error
E0024	Error	Excess Servo Velocity Error
E0027	Error	Encoder Amplitude Low - External
E0028	Error	Encoder Amplitude High - External
E0033	Error	Excess Difference in Position Feedback
E0080	Error	Variable Torque Limit Error
E0100	Error	Drive Not Configured
E0101	Error	Amplifier Temperature Sensor Error - High
E0102	Error	Amplifier Temperature Sensor Error - Low
W0103	Warning	Amplifier Temperature High Warning
E0104	Error	Amplifier Temperature High Error
E0105	Error	Amplifier Temperature High Error with Drive Enabled
E0120	Error	Motor Not Standstill During Enable
E0205	Error	EtherCAT Watchdog Timeout
E0206	Error	Configuration Mode Watchdog Timeout
E0210	Error	PSU Main Power Start Timeout Error
E0211	Error	PSU Error
E0215	Error	Encoder Adjusted Amplitude Low - Motor
E0216	Error	Encoder Adjusted Amplitude High - Motor
E0220	Error	Control Unit Synchronization Bit Toggle Missing
E0221	Error	Distributed Clocks Error
E0227	Error	Encoder Adjusted Amplitude Low - External
E0228	Error	Encoder Adjusted Amplitude High - External
E0302	Error	DC Bus Voltage High
E0303	Error	DC Bus Voltage Low
E0304	Error	Positive Position Soft Limit
E0305	Error	Negative Position Soft Limit
E0306	Error	Positive Position Dead stop
E0307	Error	Negative Position Dead stop
E0308	Error	Instantaneous Current Limit Exceeded
E0309	Error	Amplifier I2R Overload
E0320	Error	Motor I2T Overload

W0321	Warning	Amplifier I2R Warning
W0322	Warning	Motor I2T Warning
W0324	Warning	Motor I2R Warning
E0325	Error	Motor I2R Overload
E0330	Error	Positive Position Hard Limit
E0331	Error	Negative Position Hard Limit
E0332	Error	Positive Velocity Hard Limit
E0333	Error	Negative Velocity Hard Limit
E0340	Error	Invalid Command Reference Frame
E0380	Error	Event Detection Error
E0402	Error	DQA Invalid Movement Detected
E0403	Error	Alignment Off Index Pulse Error
E0404	Error	DQA Current Magnitude Error
E0405	Error	DQA Current Control Error
E0406	Error	Absolute Encoder Alignment Error
I0409	Info	Field Orientation Alignment in Progress
E0411	Error	Acceleration Observer Excessive Movement
E0412	Error	Acceleration Observer Current Control Error
E0413	Error	Acceleration Observer Excessive Velocity
E0414	Error	Acceleration Observer Torque Response Amplitude
E0415	Error	Acceleration Observer Torque Response Amplitude
E0416	Error	Acceleration Observer Validation Failed
E0417	Error	Acceleration Observer Current Magnitude Error
I0666	Info	Too Many Errors
W1002	Warning	Task Overrun

11.3.13 Error / Warning Codes Detailed Descriptions

Current Offset Adapt Error — E0007

Description Calibrated current offset value has exceeded the specified tolerance. Possible causes for this error are:

1. Fault in the current measurement system.
2. Incorrect current scaling parameters configured.

Severity Error

Encoder Amplitude Low - Motor — E0015

Description The magnitude of the signals coming from the motor analogue encoder is too low. Possible causes for this error are:

1. Encoder cable is disconnected.
2. Encoder cable is wired incorrectly.
3. Encoder is not analogue.
4. Encoder is not outputting the correct voltage.
5. Encoder is faulty.
6. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Encoder Amplitude High - Motor — E0016

Description The magnitude of the signals coming from the motor analogue encoder is too high. Possible causes for this error are:

1. Encoder cable is wired incorrectly.
2. Encoder is not analogue.
3. Encoder is not outputting the correct voltage.
4. Encoder is faulty.
5. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Excess Servo Position Error — E0023

Description Position following error exceeded the configured threshold. Possible causes for this error are:

1. Contouring commands too demanding.
2. Insufficient DC bus voltage.
3. Poor controller tuning.
4. Axis has crashed or jammed.
5. Field orientation alignment is inaccurate (possible encoder fault).

Severity Error

Excess Servo Velocity Error — E0024

Description Velocity following error exceeded the configured threshold. Possible causes for this error are:

1. Contouring commands too demanding.
2. Insufficient DC bus voltage.
3. Poor controller tuning.
4. Axis has crashed or jammed.
5. Field orientation alignment is inaccurate (possible encoder fault).

Severity Error

Encoder Amplitude Low - External — E0027

Description The magnitude of the signals coming from the external analogue encoder is too low. Possible causes for this error are:

1. External encoder configured where no encoder exists.

2. Encoder cable is disconnected.
3. Encoder cable is wired incorrectly.
4. Encoder is not analogue.
5. Encoder is not outputting the correct voltage.
6. Encoder is faulty.
7. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Encoder Amplitude High - External E0028

Description The magnitude of the signals coming from the external analogue encoder is too high. Possible causes for this error are:

1. Encoder cable is wired incorrectly.
2. Encoder is not analogue.
3. Encoder is not outputting the correct voltage.
4. Encoder is faulty.
5. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Excess Difference in Position Feedback E0033

Description The difference between motor and external feedback is greater than the configured threshold. Possible causes for this error are:

1. Incorrect encoder line count.
2. Incorrect gear box ratio and/or feed constant.
3. Faulty drive mechanism (eg. loss coupling).
4. Faulty encoder.
5. Fault drive. Please contact ANCA Motion for support.

Severity Error

Variable Torque Limit Error E0080

Description Configuration of the variable torque limit is invalid. The minimum torque limit is configured larger than the maximum torque limit.

Severity Error

Drive Not Configured E0100

Description The drive has been enabled before being configured

Severity Error

Amplifier Temperature Sensor Error - High E0101

Description Drive power stage temperature sensor is reading a value higher than the drive's sensor operating range. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Amplifier Temperature Sensor Error - Low E0102

Description Drive power stage temperature sensor is reading a value lower than the drive's sensor operating range. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Amplifier Temperature High Warning W0103

Description The drive amplifier (power stage) temperature exceeds the hardware's warning level. Possible causes for this error are:

1. Operating environment is outside specification.
2. Drive ventilation is insufficient.

3. Application is too demanding.
4. Cooling fan is faulty. Please contact ANCA Motion for support.

Severity Warning

Amplifier Temperature High Error E0104

Description The drive amplifier (power stage) temperature exceeds the hardware's physical operating threshold. Possible causes for this error are:
1. Operating environment is outside specification.
2. Drive ventilation is insufficient.
3. Application is too demanding.
4. Cooling fan is faulty. Please contact ANCA Motion for support.

Severity Error

Amplifier Temperature High Error with Drive Enabled E0105

Description With the drive enabled the drive amplifier (power stage) temperature exceeds the hardware's physical operating threshold. Possible causes for this error are:
1. Operating environment is outside specification.
2. Drive ventilation is insufficient.
3. Application is too demanding.
4. Cooling fan is faulty. Please contact ANCA Motion for support.

Severity Error

Motor Not Standstill During Enable E0120

Description When the drive is enabled the motor must be stationary. This error is triggered if the motor moves during initialisation. Possible causes for this error are:
1. Motor is moving via some external interaction during initialisation.
2. Analogue encoder feedback is excessively noisy (if applicable).
3. Standstill threshold is set below the analogue encoder feedback noise floor (if applicable).
4. Encoder is faulty.
5. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

EtherCAT Watchdog Timeout E0205

Description This error indicates a problem with communications between the EtherCAT Master (eg. CNC) and the drive. Please contact ANCA Motion for support.

Severity Error

Configuration Mode Watchdog Timeout E0206

Description This error indicates a problem with communications between ANCA MotionBench software and the drive. Please refer to *9 Start-up*

Severity Error

PSU Main Power Start Timeout Error E0210

Description The main power supply failed to enable within the configured time. Please contact ANCA Motion for support.

Severity Error

PSU Error E0211

Description The main power supply has reported an error. Please contact ANCA Motion for support.

Severity Error

Encoder Adjusted Amplitude Low - Motor E0215

Description	The magnitude of the adjusted signals for the motor analogue encoder is too low. Incorrect gain and/or offset values have been configured.
Severity	Error

Encoder Adjusted Amplitude High - Motor E0216

Description	The magnitude of the adjusted signals for the motor analogue encoder is too high. Incorrect gain and/or offset values have been configured.
Severity	Error

Control Unit Synchronization Bit Toggle Missing E0220

Description	This error indicates a problem with communications between the EtherCAT Master (eg. CNC) and the drive. Please contact ANCA Motion for support.
Severity	Error

Distributed Clocks Error E0221

Description	This error indicates a problem with communications between the EtherCAT Master (eg. CNC) and the drive. Please contact ANCA Motion for support.
Severity	Error

Encoder Adjusted Amplitude Low - External E0227

Description	The magnitude of the adjusted signals for the external analogue encoder is too low. Incorrect gain and/or offset values have been configured.
Severity	Error

Encoder Adjusted Amplitude High - External E0228

Description	The magnitude of the adjusted signals for the external analogue encoder is too high. Incorrect gain and/or offset values have been configured.
Severity	Error

DC Bus Voltage High E0302

Description	DC bus voltage in the power stage exceeded the hardware maximum limit. Possible causes for this error are: 1. Regenerative load is outside the specification for the drive. 2. Mains supply voltage is too high. 3. Regeneration resistor or drive is faulty. Please contact ANCA Motion for support.
Severity	Error

DC Bus Voltage Low E0303

Description	DC bus voltage in the power stage is below the hardware minimum limit. Possible causes for this error are: 1. Mains supply is not connected. 2. Connector for external inductor, missing inductor or link across P1, P2. 3. Mains supply voltage is too low. 4. Power requirements for the application are outside the specification for the drive. 5. Drive is faulty. Please contact ANCA Motion for support.
Severity	Error

Positive Position Soft Limit E0304

Description
Position soft limit in the positive direction has been exceeded. Possible causes for this error are:
1. Error limit is enabled before the axis has been successfully homed.
2. Master or other High Level Function have commanded the drive to a state (position & velocity) where it will be unable to decelerate before exceeding the positive position limit.
3. Drive has experienced a fault which has resulted in a runaway event.

Severity
Error

Negative Position Soft Limit E0305

Description
Position soft limit in the negative direction has been exceeded. Possible causes for this error are:
1. Error limit is enabled before the axis has been successfully homed.
2. Master or other High Level Function have commanded the drive to a state (position & velocity) where it will be unable to decelerate before exceeding the negative position limit.
3. Drive has experienced a fault which has resulted in a runaway event.

Severity
Error

Positive Position Dead stop E0306

Description
Position positive dead stop input is active.

Severity
Error

Negative Position Dead stop E0307

Description
Position negative dead stop input is active.

Severity
Error

Instantaneous Current Limit Exceeded E0308

Description
One or more of the motor phase currents has exceeded the instantaneous limit. Possible causes for this error are:
1. Instantaneous current limit is configured too low given the unified current limit.
2. Current loop is poorly tuned.
3. Motor is faulty.
4. Drive is faulty. Please contact ANCA Motion for support.

Severity
Error

Amplifier I2R Overload E0309

Description
Residual heat within the drive power stage (amplifier) exceeds the thermal limit. Possible causes for this error are:
1. Application is outside the specification for the drive: too demanding.
2. Current controller is poorly tuned.
3. Field orientation alignment is inaccurate (possible encoder fault).
4. Drive is faulty. Please contact ANCA Motion for support.

Severity
Error

Motor I2T Overload E0320

Description
Motor current is consistently higher than the specified load threshold. Possible causes for this error are:
1. Load on axis is above configured threshold.
2. Axis has crashed or jammed.

Severity
Error

Amplifier I2R Warning W0321

Description Residual heat within the drive power stage (amplifier) exceeds the warning level. Possible causes for this error are:
1. Application is outside the specification for the drive: too demanding.
2. Current controller is poorly tuned.
3. Field orientation alignment is inaccurate (possible encoder fault).
4. Drive is faulty.

Please contact ANCA Motion for support.

Severity Warning

Motor I2T Warning W0322

Description Motor current is higher than the specified load threshold. Possible causes for this error are:
1. Load on axis is above configured threshold.
2. Axis has crashed or jammed.

Severity Warning

Motor I2R Warning W0324

Description Residual heat within the motor exceeds the warning level. Possible causes for this error are:
1. Application is outside the specification for the motor: too demanding.
2. Current controller is poorly tuned.
3. Field orientation alignment is inaccurate (possible encoder fault).
4. Motor is faulty.

Severity Warning

Motor I2R Overload E0325

Description Residual heat within the motor exceeds the thermal limit. Possible causes for this error are:
1. Application is outside the specification for the motor: too demanding.
2. Current controller is poorly tuned.
3. Field orientation alignment is inaccurate (possible encoder fault).
4. Motor is faulty.

Severity Error

Positive Position Hard Limit E0330

Description Position hard limit in the positive direction has been exceeded. Possible causes for this error are:
1. Error limit is enabled before the axis has been successfully homed.
2. Master or other High Level Function has commanded the drive to a position that exceeds the positive position limit.
3. Drive has experienced a fault which has resulted in a runaway event.

Severity Error

Negative Position Hard Limit E0331

Description Position hard limit in the negative direction has been exceeded. Possible causes for this error are:
1. Error limit is enabled before the axis has been successfully homed.
2. Master or other High Level Function have commanded the drive to a position that exceeds the negative position limit.
3. Drive has experienced a fault which has resulted in a runaway event.

Severity Error

Positive Velocity Hard Limit E0332

Description Positive velocity hard limit has been exceeded. Possible causes for this error are:

1. Master or other High Level Function has commanded the drive to a velocity that exceeds the positive velocity limit.
2. Drive has experienced a fault which has resulted in a runaway event.

Severity Error

Negative Velocity Hard Limit E0333

Description Negative velocity hard limit has been exceeded. Possible causes for this error are:
1. Master or other High Level Function have commanded the drive to a velocity that exceeds the negative velocity limit.
2. Drive has experienced a fault which has resulted in a runaway event.

Severity Error

Invalid Command Reference Frame E0340

Description The set point command is in referenced coordinates, that is zeroed or homed, but the feedback is not in reference coordinates. Handshaking between the master and the drive while attempting to change referenced coordinates has failed.

Severity Error

Event Detection Error E0380

Description The event detection module has reported an error while attempting to latch a position during homing or probing. Please contact ANCA Motion for support.

Severity Error

DQA Invalid Movement Detected E0402

Description During DQ alignment an invalid movement was detected. Possible causes for this error are:
1. Incorrect motor poles configured.
2. Incorrect motor phase sequence.
3. Incorrect motor encoder line count configured.
4. Incorrect motor encoder polarity configured.
5. The configured alignment current is too low to drive the motor.
6. Motor/axis is jammed.

Severity Error

Alignment Off Index Pulse Error E0403

Description The difference between the configured and estimated field orientation alignment offset is larger than the configured threshold. Possible causes for this error are:
1. Incorrect encoder configuration (i.e. UVW hexant binary).
2. The relative position between the motor and encoder has been modified.

Severity Error

DQA Current Magnitude Error E0404

Description The configured alignment current exceeds the unified current limit.

Severity Error

DQA Current Control Error E0405

Description Sensed motor current is not following the DQ alignment current with sufficient accuracy, Possible causes for this error are:
1. Poorly tuned current loop.
2. DC bus voltage too low.
3. Motor armature cable is disconnected.
4. Motor is faulty.
5. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Absolute Encoder Alignment Error E0406

Description Absolute encoder used for field orientation initialisation has failed to latch an alignment angle. Possible causes for this error are:

1. Encoder is faulty. Power cycling the drive/encoder may resolve the issue.
2. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Field Orientation Alignment in Progress I0409

Description Field Orientation Alignment is in progress - active stimulus signal (current) has been commanded to the motor.

Severity Info

Acceleration Observer Excessive Movement E0411

Description Motor movement exceeded tolerance while executing acceleration observer field orientation. Possible causes for this error are: 1. Incorrect motor poles configured. 2. Incorrect motor phase sequence. 3. Incorrect motor encoder line count configured. 4. Incorrect motor encoder polarity configured.

Severity Error

Acceleration Observer Current Control Error E0412

Description Sensed motor current is not following the Acceleration Observer alignment current with sufficient accuracy, Possible causes for this error are:

1. Poorly tuned current loop.
2. DC bus voltage too low.
3. Motor armature cable is disconnected.
4. Motor is faulty.
5. Drive is faulty. Please contact ANCA Motion for support.

Severity Error

Acceleration Observer Excessive Velocity E0413

Description Excessive velocity detected while acceleration observer is executing. Possible causes for this error are:

1. Incorrect motor poles configured.
2. Incorrect motor encoder line count configured.
3. Stimulus frequency is too low.
4. Stimulus current is too high.

Severity Error

Acceleration Observer Torque Response Amplitude Low E0414

Description The fundamental frequency component of the torque response is below the minimum amplitude threshold. Possible causes for this error are:

1. Stimulus frequency is too high.
2. Stimulus current is too low.

Severity Error

Acceleration Observer Torque Response Amplitude High E0415

Description The fundamental frequency component of the torque response is above the maximum amplitude threshold. Possible causes for this error are:

1. Stimulus frequency is too low.
2. Stimulus current is too high.

Severity Error

Acceleration Observer Validation Failed E0416

Description The axis moved in the wrong direction after Acceleration Observer completed. Possible causes for this error are:

1. Incorrect motor poles configured.
2. Incorrect motor phase sequence.
3. Incorrect motor encoder line count configured.
4. Incorrect motor encoder polarity configured.
5. The configured stimulus current is too low.
6. The configured stimulus frequency is too high.

Severity Error

Acceleration Observer Current Magnitude Error E0417

Description Stimulus current magnitude exceeds the unified current limit.
Severity Error

Too Many Errors I0666

Description Multiple errors have been tripped; for the detailed list of error refers to P-0488 (33256).
Severity Info

Task Overrun W1002

Description One or more of the internal tasks has exceeded their maximum execution time. Please contact ANCA Motion for support.
Severity Warning

11.3.14 Firmware Upgrade Errors

Displayed state	Description
BOOT1	Boot loader started
BOOT2	Boot loader finished
BLUP0	Boot loader Updater: Firmware processing state idle
BLUP1	Boot loader Updater: Firmware processing state validate after write
BLUP2	Boot loader Updater: Firmware processing state finished
E0001	EFW Streaming error: unexpected flash programming in progress
E0002	EFW Streaming error in receiving the file header
E0003	EFW Streaming error in validating the file header (CRC)
E0004	EFW Streaming error in initializing flash programming
E0005	EFW Streaming error in receiving the image block header
E0006	EFW Streaming error while decrypting the image block header
E0007	EFW Streaming error in validating the image block header (CRC)

E0008	EFW Streaming error: unexpected flash erasing or writing in progress while receiving the image block header
E0009	EFW Streaming error: software image size is larger than the allocated receiving buffer
E0010	EFW Streaming error in receiving the software image header
E0011	EFW Streaming error in decrypting the software image header
E0012	EFW Streaming error in validating the software image header (CRC)
E0013	EFW Streaming error: unexpected flash erasing or writing in progress while receiving the software image header
E0014	EFW Streaming error in receiving the software image data
E0015	EFW Streaming error in decrypting the software image data
E0016	EFW Streaming error: flash interface is not enabled while finalizing image stage 1
E0017	EFW Streaming error in validating the image block (CRC)
E0018	EFW Streaming in validating the software image
E0019	EFW Streaming error: flash interface is not enabled while finalizing image stage 2
E0020	EFW Streaming error in validating the file (CRC)
E0021	Boot loader Updater error: boot loader CRC check failed
E0022	Boot loader Updater Firmware Processing error: Flash controller interface error while preparing to write
E0023	Boot loader Updater Firmware Processing error: Flash controller interface error while submitting a block to be written
E0024	Boot loader Updater Firmware Processing error: Flash controller interface programming error
E0025	Boot loader Updater Firmware Processing error: Flash has attempted to write to the boot loader sector in flash but was unsuccessful, wipe the boot loader
E0026	Boot loader Updater error: The attempt to erase the first sector of the application section (this has the jump instruction and header) failed.

12. Technical Data

12.1 What this Chapter Contains

This chapter contains information related to detailed specifications of the drive:

- Control Functions
- Interface Specifications
- Electrical Specifications
- Performance Specifications
- Environmental Specifications
- Mechanical Dimensions and details
- Standards Compliance

12.2 Control Functions

Attribute	***Qualification***
12.2.11 Control Modes	
Linear control	Yes
Rotational control	Yes
Position control (with cyclic position commands)	Commands received via the Ethernet interface/EtherCAT protocol
Velocity control	Commands received via the Ethernet interface/EtherCAT protocol
Current/Torque control	Yes
Sinusoidal Induction Motor Control	Yes
12.2.12 Thermal and over-current protection	
Inverter heat-sink temperature limit	70° C
I versus T adjustable limiting	Yes
Adjustable over-current trip	Yes
Surge protection	Yes (300 VAC)
12.2.13 Self-Protection features	
Motor Overload	Yes
Over-travel Limit exceeded	Yes
12.2.14 DC bus voltage control	
Bus voltage monitor	Yes

Bus regeneration brake chopper	Yes
Bus over/under voltage adjustable limits	Yes

12.2.15 Advanced control functions

Drive controlled homing	Yes
DC Bus compensation	Yes
Cogging compensation	No
Backlash compensation	No
Probing	No
Pre-defined Drive Controlled Moves (DCM)	Yes – up to 64 move segments
Drive controlled Homing (DCH)	Yes
Field Orientation Modes	• DQ Alignment • Acceleration Observer • Hall Sensors • Fixed
EtherCAT Slave Mode	Yes
EtherCAT Slave to Slave Communication	Yes
Stand-alone Mode	Yes
Field Firmware Updates	Yes
Position Latch	Yes
Secure Boot Loader	Yes
Persistent Configuration Data	Yes (via EEPROM)
Continuous ADC Calibration	Yes

12.3 Interface Specifications

Attribute	*Qualification*
12.3.11 Digital I/O Supply	
Nominal Operating Voltage	24 VDC ±10%
Maximum Current	500 mA
Short Circuit Protected	Yes (resettable fuse)
12.3.12 24V Digital Inputs	
Number of Inputs	8
Nominal Operating Voltage	24 V
Maximum Voltage	30 V
Minimum Input Must Detect Voltage	18 V
Maximum Must Not Detect Input Voltage	5 V
Input Current	16 mA
Input Impedance	1 kΩ
Isolated	Yes
12.3.13 24V Digital Outputs	
Number of Outputs	6
Output Type	NPN Open Collector
Nominal Operating Voltage	24 V
Maximum Operating Voltage	30 V
Maximum Sink Current	300 mA total for all 6 outputs while not exceeding 300 mA per output [1]
Isolated	Yes
Short Circuit Protected	No
12.3.14 5V RS422 Differential Digital Inputs	
Number of Inputs	2 *(4 wires)*
Absolute Maximum Voltage on Any Line W.R.T. 0V	+12/-7 V
Turn On Differential Threshold	+200 mV
Turn Off Differential Threshold	-200 mV
Hysteresis	45 mV
Isolated	No
12.3.15 Differential Digital Outputs	
Number of Outputs	3 x line driver (6 wires)
Minimum Output High Voltage single ended W.R.T	2.5 V @ 20 mA

GND	
Maximum Output Low Voltage single ended W.R.T GND	0.5 V @ -20 mA
Maximum Current	±20 mA
Isolated	No
Short Circuit Protected	No

12.3.16 Analogue Inputs

Number of Inputs	2
Input impedance	5.9 kΩ
Input Voltage (Nominal Range)	±10 V
Input Voltage (Absolute Maximum Range)	±12.64 V
Bandwidth	318 Hz
Isolated	No

12.3.17 Analogue Outputs

Number of Outputs	1
Output Voltage (Nominal Range)	±10 V
Output Voltage (Absolute Maximum Range)	±12.25 V
Output Current (Nominal)	+/-10 mA
Short circuit protection	Yes
Bandwidth	500 Hz
Isolated	No

12.3.18 Motor Position Feedback

Number of position feedback channels	2 Ch1: Analogue 1 Vpp Ch2: RS422 Line Drive
Supported Encoders	• Analogue Incremental Sin/Cos (1 Vpp) • Digital Incremental (RS422)

12.3.19 Encoder Channel 1

Interface Type	Analogue 1 Vpp
Supported Inputs	Sin, Cos (1Vpp), Ref (RS485)
1Vpp Commutation Track	Not Supported
1Vpp Terminating Resistance	120 Ω
1Vpp Full Scale Differential Input Voltage	1.6 Vpp
1Vpp Bandwidth	200 kHz
RS485 Terminating Resistance	140 Ω
RS485 Turn On Differential Threshold	+200 mV
RS485 Turn Off Differential Threshold	-200 mV

RS485 Hysteresis	50 mV
RS485 Common Mode Range	-0.7 V to +5.6 V

12.3.20 Encoder Channel 2

Interface Type	RS422 Line Receiver
Number of Inputs	3 (6 wires)
Maximum Voltage on Any Line W.R.T. 0V	+12/-7 V
Terminating Resistance	120 Ω in series with 1 nF capacitance
Turn On Differential Threshold	+200 mV
Turn Off Differential Threshold	-200 mV
Hysteresis	45 mV
Isolated	No

12.3.21 Encoder Supply

Nominal Voltage	5VDC +-5% unregulated supply 9VDC +-5% regulated supply
Maximum Current	400mA (5VDC) 500mA (9VDC)
Short Circuit Protection	No

12.3.22 Ethernet Interface

Protocol	EtherCAT
Baud Rate	100 Mb/s
Drive Profile Definition	SoE
Connector	Ethernet RJ-45

12.3.23 Modbus Interface

Baud Rate	19200 b/s
Connector	RJ-45

12.3.24 Drive Display

Indicator	5 x 7-segment LED
Operator Interfacing	4 DIP buttons

12.3.25 Digital I/O Supply

Nominal Voltage	24VDC ±10%
Maximum Current	500 mA (X4 pins 20/21 combined)
Short Circuit Protected	Yes (resettable fuse)

[1] Exceeding these written values may damage the drive and will cause unexpected operation of the digital outputs. These outputs are ‘open collector’ type and have no current limiting or diagnostic features. It is up to the customer to ensure compatibility of the external circuitry with this limit.

12.4 Electrical Specifications

		Catalogue Number	
		D2003-2S1-A	**D2009-2S1-A**
Attribute	***Symbol***	***Qualification***	
12.4.11 Power supply section			
Drive Input voltage	$U_{LN\text{-}(1Ø)}$ $U_{LL\text{-}(3Ø)}$	100~240VAC 100~240VAC	
Voltage fluctuation	U_{δ}	+/- 10%	
Input frequency	f_{LN}	50/60Hz	
Maximum input voltage to Protective Earth	$U_{L1,L2,L3\text{-}PE}$	265V AC	
Auxiliary input current	I_{LN}	500 mA	
Soft Start Relay		Internal	
12.4.12 Digital servo drive			
DC voltage	U_{DC}	1.404x$U_{\mathrm{LN\text{-}(1Ø\text{-}3\,Ø)}}$	
Max. output voltage	U_{aN1}	0.90x $U_{\mathrm{LN\text{-}(1Ø\text{-}3\,Ø)}}$	
Continuous output current	I_{aN}	3 A rms	9 A rms
One-minute overload capability	I_{aM}	110%	
Peak repetitive overload current	I_p	6 A rms	16 A rms
Max. Peak repetitive overload duration	t_p	1 sec	
Min. Peak repetitive overload interval	t_s	10 sec	
Current loop update rate	t_i	62.5 µsec, 125 µsec*	
Drive efficiency	η_D	>90%	
Max. Output frequency (at nominal U_{LN})	f_{max}	500 Hz	

* 125 µsec under development.

12.5 Performance Specifications

	Catalogue Number	
	D2003-2S1-A	**D2009-2S1-A**
Attribute	***Qualification***	
12.5.11 Resolution		
Analogue to Digital	12 Bits	
12.5.12 Steady State Performance		
Accuracy at recommended operating conditions	±2 encoder counts	
12.5.13 Dynamic Performance		
Max. settling time	[13]	
Current loop response	[14]	
12.5.14 Regenerative Braking		
Regenerative brake switching capacity	3A at U_{DC}	9A at U_{DC}
Internal Brake Resistor	40 Watts	60 Watts
External Brake Resistor	Optional	

[13] Depends on current/velocity/position control loop tuning
[14] Depends on current/velocity/position control loop tuning

12.6 Environmental Specifications

	Catalogue Number	
	D2003-2S1-A	D2009-2S1
Attribute	***Qualification***	
12.6.11 Storage		
Ambient Temperature	-20 to +65° C	
Relative Humidity	5 to 90%	
12.6.12 Transport		
Ambient Temperature	-20 to +65° C	
Relative Humidity	90% at 40° C	
Mechanical vibration	5.9m/s^2 maximum	
12.6.13 Installation and Operation		
Permissible Ambient Temperature at rated continuous current I_{aN}	0 to +50° C	
Maximum Ambient Temperature with de-rating[15]	+55° C	
Relative Humidity	5 to 85% non-condensing	
Mechanical vibration	5.9 m/s2 maximum	
Unusual environmental conditions	Not provided beyond 60146-1-1	
Maximum installation/operating altitude (with respect to mean sea level)	1000	
12.6.14 Physical Characteristics		
Degree of Protection	IP20 in accordance with 60529	
Mounting position in Operation	Vertical	
Device Weight	1.25kg	2kg
Height (mm)	206	182
Width (mm)	43	60
Depth (mm)	189	185
12.6.15 Cooling		
Fan Cooled	No	Yes
Heat generation @ full rated continuous current[2]	31 W	80 W

[15] De-rating is applied to the maximum rated continuous current I_{aN} from 100% at 50°C down to 50% at 60°C

[2] This amount of heat energy needs to be removed from the equipment cabinet to prevent overheating

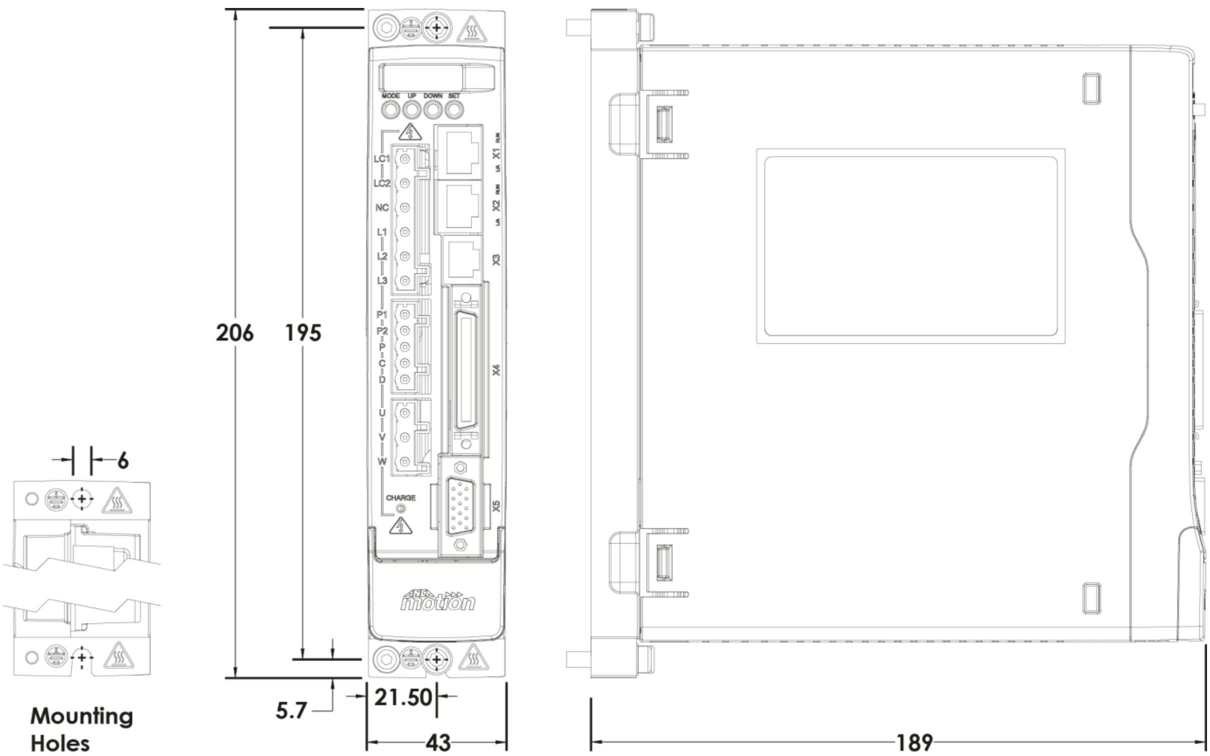
†Note: Degree of Protection

Both 3A and 9A AMD2000 drives comply with EN 60529, IP20.

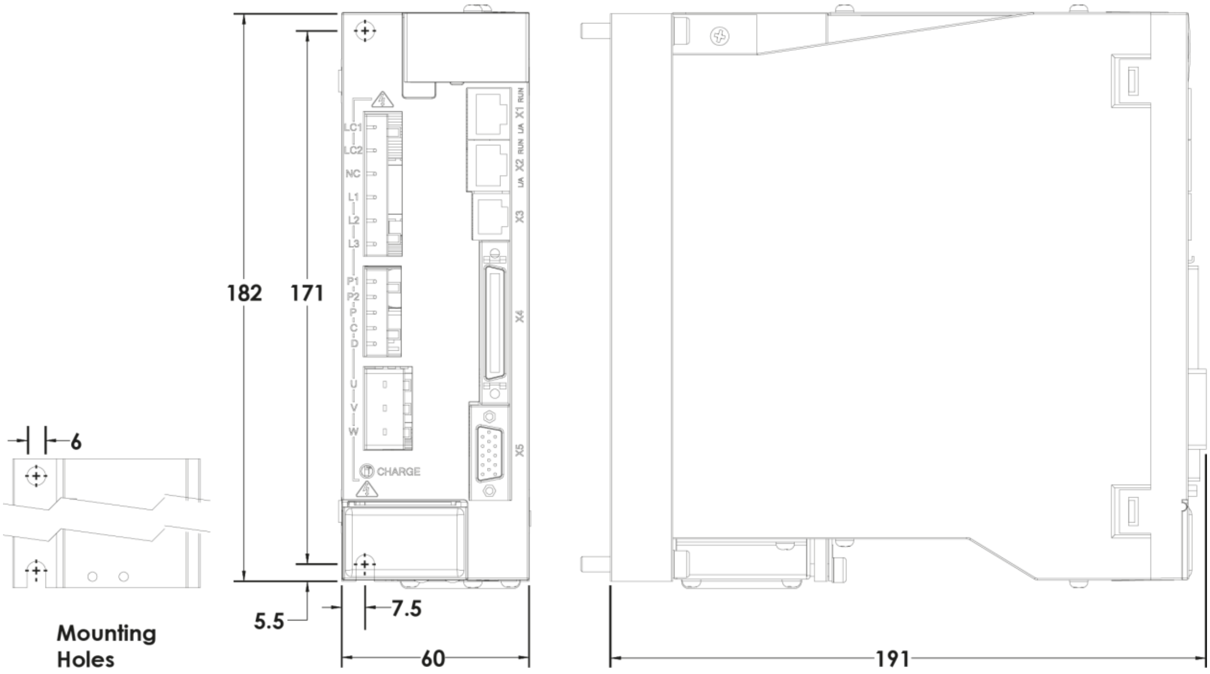
NOTE: The top surface of cabinets/enclosures which are accessible when the equipment is energized shall meet at the requirement of protective type IP3X with regard to vertical access only.

12.7 Dimension Drawings

12.7.11 AMD2000 3A drive mounting hole positions and physical dimensions



12.7.12 AMD2000 9A drive mounting hole positions and physical dimensions

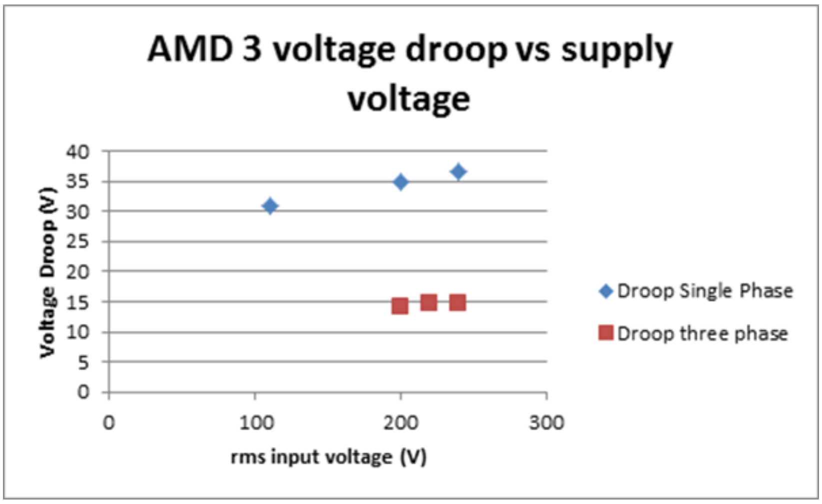


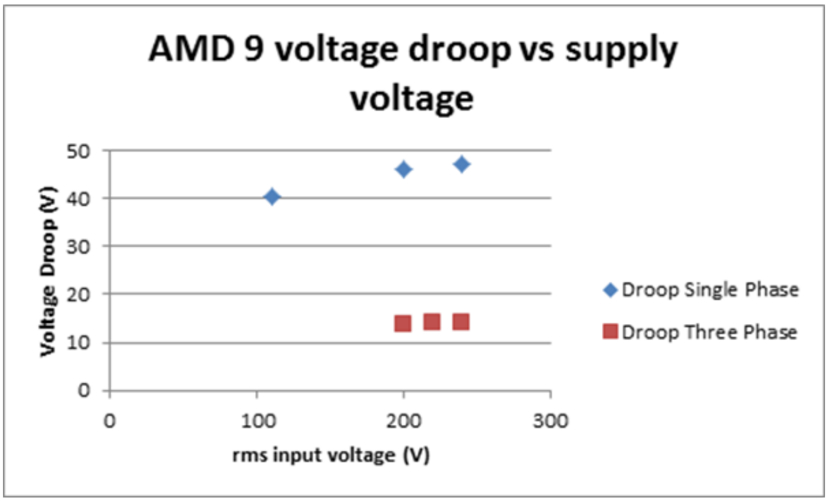
12.8 24V Control Circuit Supply

The maximum current that can be drawn from this supply is 500mA total. Note that if a motor with a brake is required this may be insufficient current to release the brake, so an external power supply will be required. Also note that if overloaded the poly-fuse in the drive will present a high resistance and there will no longer be 500mA available until the load is removed.

12.9 Effect of AC Input Voltage on DC Bus Ripple

The AMD 2000 drive works by rectifying AC into DC to generate what is known as a DC Bus. This is smoothed by the bus capacitance and then 6 switches turn on in such a manner that rotation of the motor occurs. Because there is a finite capacitance in the drive there will always be voltage ripple when the drive is providing energy to a motor. The higher the input voltage is to the drive, and the more power that is drawn from the drive, the higher the ripple. Specified in the graphs below is voltage droop, which is the value the voltage drops at its lowest point. These are all for full rated current for both of the drives. Because the power output has dropped as the voltage decreases the ripple drops also, which is somewhat counter-intuitive. For a constant power load decreasing input voltage would result in increased ripple.





Load will also affect ripple and droop. If the load is decreased the ripple will decrease, but the relationship is not linear. Either simulation, testing or solution of non-linear equations is required to find the droop that will result in a changed load with fixed AC input voltage and capacitance.

12.9.11 Effect of AC Input Voltage on DC Bus Voltage

For a delta connected supply or a single phase supply the input voltage will be approximately

$$1.414 \times (AC\ input\ voltage) - (\frac{DC\ bus\ ripple}{2})$$

12.9.12 Effect of Bus Capacitance on DC Bus Ripple

The selection of bus capacitance required for a user application is based on the amount of power required and the amount of ripple desired. Increasing the bus capacitance can result in more power output (higher rms output voltage as ripple reduces) and lower voltage ripple.

As well as this, sharing of the ripple current over more capacitors meaning less heating and longer life of the bus capacitors. This also may reduce the requirement of regeneration resistors as the increase in capacitance lowers the voltage increase of the capacitors. It may result in higher peak currents from the supply however, and associated conducted harmonic current emissions, so recommended ANCA Motion inductors will no longer be applicable.

The bus capacitors must support the DC bus voltage between charging. With three phase input at 50 Hz this would be 1/300 = 3.33ms. An approximation to find the voltage drop is

$$V = \frac{I_{rms} \times t}{C}$$

where t = time(s) bus capacitance must support the load until it gets charged next, (3.33ms for three phase 50 Hz and 10ms for 50 Hz single phase), I_{rms} is the output current the drive is providing (A) and C is the bus capacitance (F).
Note that this will give up to 1.5 times more voltage droop than will occur in reality. As the bus capacitance increases and the load decreases this equation becomes more accurate. If exact voltage droop is desired then please contact ANCA Motion applications engineering.

Note that with increasing drive bus capacitance the inrush current upon power-up increases and the internal soft start resistor may not be sufficient to limit the charge current into the capacitors without blowing an upstream fuse. Under all circumstances, the charge current must be kept to under 20A. The internal positive temperature coefficient resistor is 50 Ohms. The maximum charge current at 240VAC input will thus be 340/50 = 6.8A.

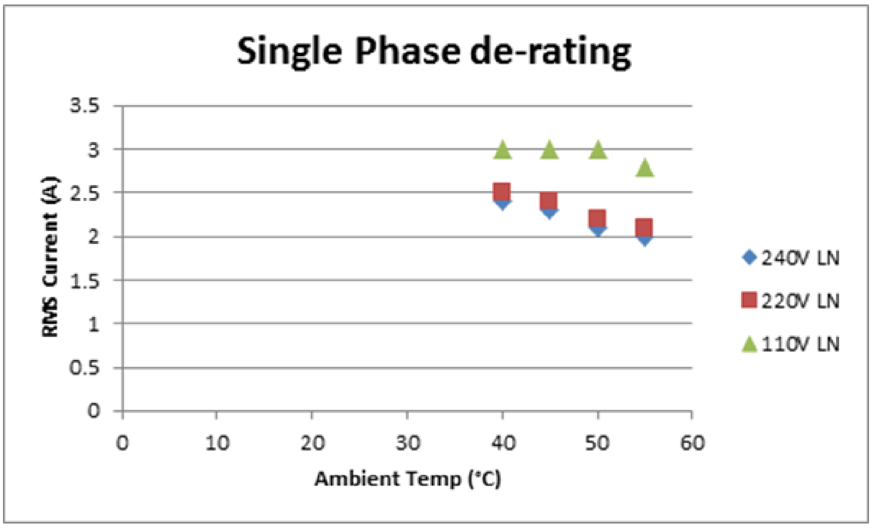
12.9.13 Effect of Output Current on DC Bus Ripple Voltage

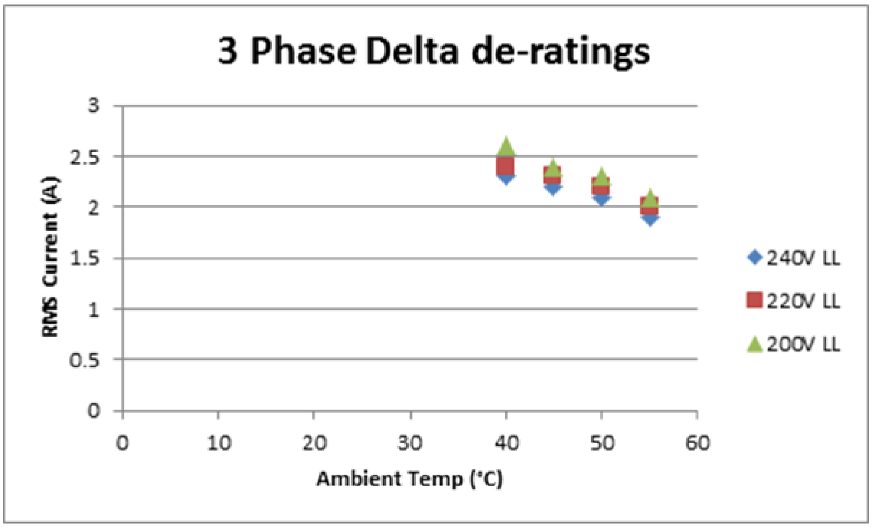
12.10 Temperature De-rating

The AMD2000 3A and AMD2000 9A drives dissipate heat via heat sinks, but the AMD3 does not use a cooling fan. In the unlikely event of fan failure under heavy load, the heat sink temperature will increase until it reaches 70°C, when the internal controller will stop power flowing from the drive to the motor and report a class 1 diagnostics error. Please see the graphs of ambient temperature and current rating below to assess safe thermal operating area. Please note, these figures apply to 50 Hz sinusoidal output and power factor 0.8 on the drive. Note that these curves may be scaled by duty cycle, so if the application only has the drive running for 0.5 duty cycle at 3 phase 55 °C ambient 240V delta supply then instead of 1.9A rms, the full 3A rms rating could be used for 50% of the time.

12.10.11 De-rating Characteristics

AMD2000 3A drive de-rating Curves





The AMD 9 has no thermal ratings curves, as the full 9A rms output may be used up to 55 °C ambient temperature and maximum voltage rating of the drive.

Note that these curves are for a single drive only. Where multiple drives are used in close proximity further de-rating may be necessary. Please see mechanical drawings below that show spacing required.

12.11 Input Power-cycling and Inrush

Upon start-up the drive will have an inrush current of no more than 6.8 A. Power cycling the drive more than once every 10 s is not recommended.

12.12 Discharge Period

If additional capacitance is added to the bus the discharge period for the bus capacitance to drain to 40V can be calculated by:

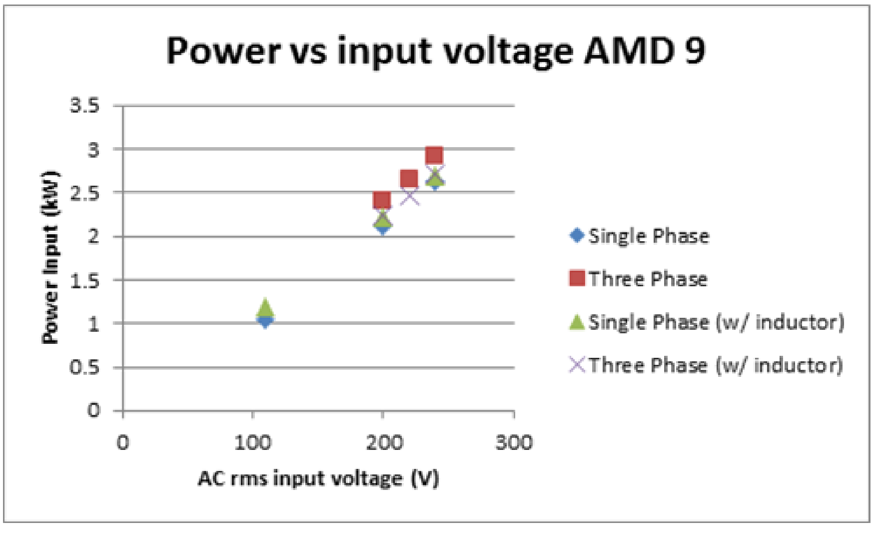
$$-\ln\left(\frac{40}{1.414 \times V_{ACin}}\right) \times \tau$$

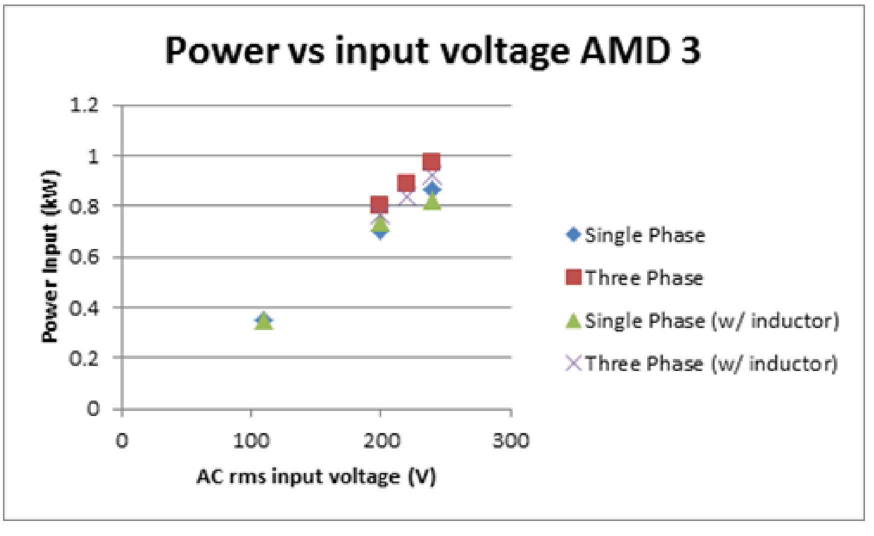
Where $\tau = (C_0 + C_{user}) \times 300 \times 10^3$

C_0 is 440×10^{-6} for AMD2000 3A drive and 1410×10^{-6} for AMD2000 9A Drive

12.13 Motor Output Power

See ratings table below: This is dependent on motor input voltage, optional harmonic suppression inductor if used and optional additional bus capacitance, and if a single or three phase supply is used. Note that the increase of power by using additional bus capacitance is not covered in the de-ratings tables. Please contact ANCA Motion applications if increased power output is required by using additional bus capacitance. Please note that final output power capability is defined by the thermal rating for the AMD2000 3A.

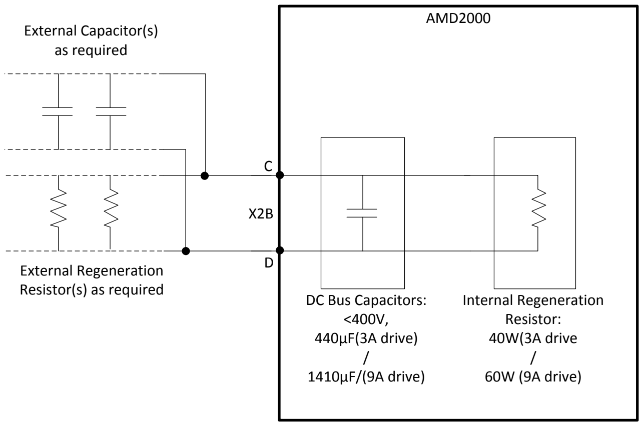




12.14 Brake/Regeneration Resistor

The AMD2000 3A and AMD2000 9A drives have an inbuilt regeneration resistor. Regeneration refers to the process whereby when the motor is actively providing energy to the drive and then stops, the kinetic energy in the entire mechanical system connected to the shaft of the motor gets transferred to the bus capacitance in the drive, which increases the voltage. This happens because of the motor inductance. When the voltage on the bus capacitance exceeds 385V the drive will connect the internal regeneration resistor in addition to any external regeneration resistor that is provided by the user. The internal resistor is only capable of dissipating a power of 40W for the AMD92000 3A and 60W for the AMD2000 9A. In addition to the power rating of the resistor to be observed the instantaneous energy maximum for each resistor must also be observed. This is 24.7 joules for the AMD 2000 3A drive and 143 joules for the AMD 9. If there is more regeneration power than this is created then the user must connect an external resistor.

In addition to the power dissipation constraint of the regeneration resistors, the internal bulk capacitance of the drive is 440µF for the AMD2000 3A and 1410µF for the AMD2000 9A with a working voltage of 400V. This value of 400V must never be exceeded. The user must calculate what the bus voltage will increase to due to the capacitance given the energy in the mechanical system. Note that if external bus capacitance is used (for smoother bus ripple) then this capacitance must be added also.



12.14.11 Brake Resistor Selection, Braking Energy and Power

The starting points for the calculations regarding the required regeneration resistor are the two equations for kinetic energy in the system, and are dependent entirely on the application of the user.

Linear:

$$E = \frac{1}{2}mv^2$$

Where E = Energy in Joules
m = mass in kg
v = velocity in m/s

Rotational:

$$E = \frac{1}{2}J\omega^2$$

Where E = energy in Joules
J = moment of inertia in kgm^2
ω = angular velocity in rad/s

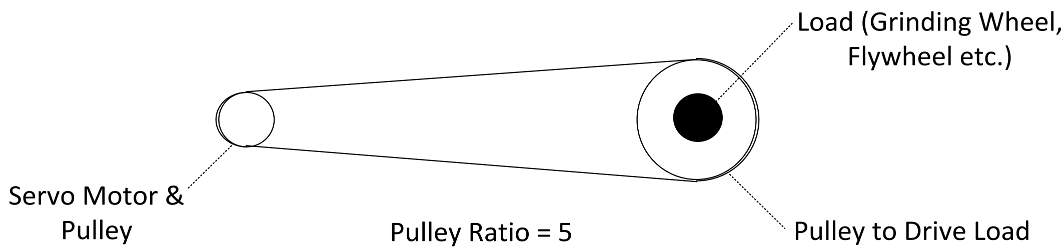
Once the kinetic energy in the system is found, the voltage rise due to the energy on the bus capacitance can be found:

$$\Delta V = \sqrt{(\frac{2E}{C})}$$

Where V = voltage in V,
E = Energy in Joules,
C = Capacitance in Farads

The power dissipated in the regeneration resistor(s) additionally depends on how often the user is stopping the torque output of the motor. For example, if the drive is operating in torque mode and a torque command is set to 0 from a non-0 value then the power dissipated is the kinetic energy in the system multiplied by the number of times per second the drive is going from this set point to 0 again.

Example 1:



The servo motor drives a load via two pulleys. The ratio is 1:5 from motor to load to provide a slower speed but higher torque.

Assuming the belt has negligible stored energy compared to the rest of the system and the load is rotational:

J_{eff} (effective moment of inertia) = $J_{motor}+J_{motor\ pulley} + \frac{1}{5}(J_{load\ pulley} + J_{load})$

The energy stored in the system at the time the torque set point is reduced to zero is:

$$E = \frac{1}{2}J_{eff}\omega^2$$

(For the inbuilt brake resistors, this value must not exceed 24.7Joules for AMD2000 3A drive and 143J for AMD2000 9 A drive.)

The rise in voltage in this example is then

$$\sqrt{(\frac{2E}{C})}$$

Example 2:

The situation in example 1 has torque applied and then stopped twice per second. The power required for the regeneration resistor to dissipate all of the energy is

$$P = Ef = E * 2$$

12.15 Materials

Drive enclosure:	The AMD2000 Drive chassis (main, sub, and fan) are stainless steel 304 with a silver paint finish. The AMD2000 Drive heat-sink is aluminium 6063 T5. The AMD2000 face cover main and PN panels are SABIC Resin 221R with a print finish on the main panel.
Packaging:	Cardboard
Disposal:	The drive contains raw materials that should be recycled to preserve energy and natural resources. The package materials are mostly environmentally compatible and recyclable. All metal parts can be recycled. The plastic parts can either be recycled or burned under controlled circumstances, according to local regulations. Most recyclable parts are marked with recycling marks. The electrolytic capacitors and the integrator power module are classified as hazardous waste within the EU and must be removed and handled according to local regulations. For further information on environmental aspects and more detailed recycling instructions, please contact your local ANCA Motion distributor.

12.16 Standards Conformity

Marking & Applicable Regulations	Standard	Certification Organisation	CAT. NO. D2003-2S1-A / AM619-0-03-0003	CAT. NO. D2009-2S1-A / AM619-0-03-0009
CE LVD 2006/95/EC (Low Voltage Directive)	EN 61800-5-1: 2007 (Class I)	Integrity EnE Lab Inc, Taiwan INTEGRITY	Report No. IL110705800 ✓	Report No. IL100812800 ✓
EMC 2004/108/EC (Electromagnetic Compatibility)	EN 61800-3:2004 (Category C3) Emissions: CISPR 11:2009/A1:2010 EN 61000-3-2:2006/A1:2009/A2:2009 EN 61000-3-3:2008 Immunity: EN 55024:2010 IEC 61000-4-2:2008 IEC 61000-4-3:2006/A1:2007/A2:2010 IEC 61000-4-4:2004/A1:2010 IEC 61000-4-5:2005 IEC 61000-4-6:2008 IEC 61000-2-4:2003 IEC 60146-1-1:1993 IEC 61000-2-1:1990	Electronics Testing Center, Taiwan ETC	Report No. 13-01-MAS-116-R ✓	Report No. 12-06-MAS-263 ✓
EtherCAT[16]	ETG 1000 series ETG 9001 ETG 1300	Note: the AMD2000 is a conforming EtherCAT device, but does not qualify as conformance tested. ANCA Motion self-determination of compliance.	✓	✓
Those items in the drive with no applicable regulation, but to which standards have been applied.	Servo profile over EtherCAT fieldbus profile (SoE). IEC 61800-7. IEC 61491, for serial data link real time communications in industrial machines.	ANCA Motion self-determination of compliance within certain limits.	✓	✓

[16] EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

12.17 EtherCAT®[17] Conformance Marking

An EtherCAT device conformance mark is attached to each drive in order to verify that the unit has been tested for compliance with the EtherCAT marking, indicator and performance guidelines covered by the ETG standards listed in section 12.16. Future drive revisions intend to achieve “Conformance tested” marking by independent verification through an externally registered body.

12.18 CE Marking

A CE mark is attached to each drive in order to verify that the unit meets the relevant Low Voltage and Electromagnetic Compliance (EMC) directives of the European Union.

12.18.11 Compliance with the European EMC Directive is achieved via EN 61800-3

The object of this standard (61800-3) is to define the limits and test methods for a Power Drive System (PDS) according to its intended use, whether residential, commercial or industrial. The standard sets out immunity requirements and requirements for electromagnetic emissions as minimums within these different environments. The AMD2000 (both 3A and 9A) are intended for use as Category 3 PDS, and have been tested and certified to comply for use within what 61800-3 defines as the second environment. The AMD2000 3A and 9A comply with the standard with the following provisions:

1. The motor and control cables are selected according the specifications given in this manual.
2. The drives are installed and maintained according to the instructions given in this manual.
3. The maximum cable lengths are 15 metres.

Warning: A drive of category C3 is not intended to be used on a low-voltage public network which supplies domestic premises. Radio frequency interference is expected if the drive is used on such a network

12.18.11.1 Definitions

First environment

Environment that includes domestic premises, it also includes establishments directly connected without intermediate transformers to a low-voltage power supply network which supplies buildings used for domestic purposes.

Second environment

Environment that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes.

Category C3 Power Drive System

Category 3 is for a PDS of rated voltage less than 1000 V, intended for use in the second environment and not intended for use in the first environment.

12.18.12 Compliance with the European Low Voltage Directive is achieved via EN 61800-5-1

The object of this standard (61800-5-1) is to specify requirements for adjustable speed Power Drive Systems (PDS) or their elements with respect to electrical, thermal and energy safety considerations. The AMD2000 (both

[17] EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

3A and 9A) are considered to be protective Class I PDS, and comply with the standard with the following provisions:

1. The drives are installed and maintained according to the instructions given in this manual.

12.18.12.1 Definitions

Protective Class I

Equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the fixed wiring of the installation, so that accessible conductive parts cannot become live in the event of a failure in the basic insulation.

12.18.13 CE Declaration of Conformity

EC Declaration of Conformity

Product: AMD2000 Series Servo Drive

Manufacturer: ANCA Motion Pty.Ltd
1 Bessemer Rd
Bayswater North
Victoria 3153
Australia

Person Authorised to Compile the Technical File in the European Community:
ANCA GmbH
Alois-Senefelder-Str.4
68167 Mannheim
Germany

This product is in conformance with the following European Directives when installed in accordance to the installation instructions contained in the product documentation:

2006/95/EC	Low Voltage Directive
2004/108/EC	EMC Directive

To demonstrate conformity, this product has been designed to adhere to the following standards:

EN 61800-5-1:2007	Adjustable Speed Electrical Power Drive systems – Part 5-1: Safety Requirements - Electrical, Thermal and Energy.
EN 61800-3:2004	Adjustable Speed Electrical Power Drive systems – Part 3: EMC Requirements and Specific Test Methods.

ANCA Motion
04/04/2013

Pat Boland
Managing Director

Product: AMD2000 Series Servo Drive

The product family, to which the CE marking applies, consists of the following components

Products under ANCA Motion Product Code control
D2009-XXX-X :Where each X is an alphanumeric character
D2003-XXX-X :Where each X is an alphanumeric character
Products under ANCA Motion Part Number control.
AM619-0-03-0003
AM619-0-03-0009
AM619-1-03-0009
619-1-03-0009

Attachment of the CE marking: 2013

13. Accessories

13.1 What this Chapter Contains

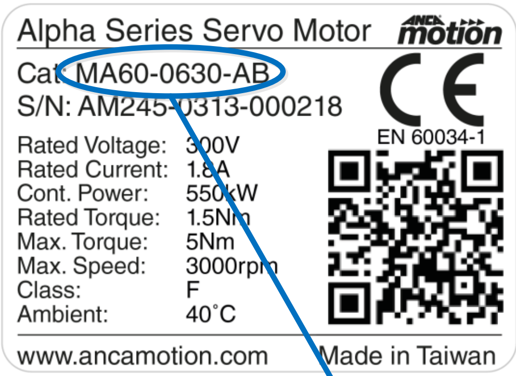
This chapter contains summarized information on accessories options available for this drive

- Ordering Information / Catalogue Number Interpretation
- Details of Accessories

For additional details, please refer to full catalogue and information available via *14.3 Product, Sales and Service Enquiries*

13.2 Motors

13.2.11 Motor Catalogue Number Interpretation



M A 6 0 - 0 6 3 0 - A B

Product
M: Motor

Series
A: Alpha Series

Frame Size
60: 60 mm square flange
80: 80 mm square flange
86: 86 mm square flange
130: 130 mm square flange

Rated Torque
06: 0.6 Nm
13: 1.3 Nm
24: 2.4 Nm
.. etc

Rated Speed
10: 1000 rpm
20: 2000 rpm
30: 3000 rpm
Refer to catalogue for full list

Feedback Type
A: Incremental Digital

Options
B: Brake

13.2.12 Motor Electrical Information Summary

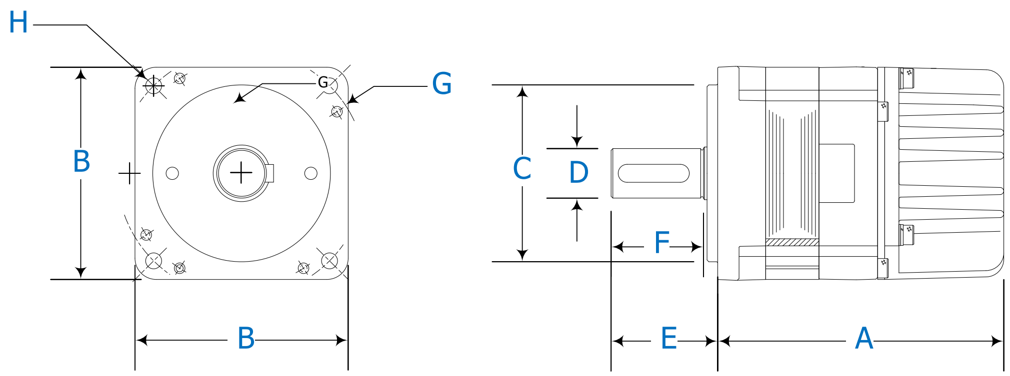
	Order code	Rated Torque (Nm)	Rated Speed (rpm)	Rated Power (W)	Rated Current (A)	Torque Constant (Nm/A)	Voltage Constant (V/krpm)	Max Current (A)	Max Speed 300 VDC bus (rpm)	Rotor Inertia (kg.cm2)	Stator Resistance (Ohm)	Stator Inductance (mH)	Motor Poles
AMD2000 D2003	MA60-630-A	0.64	3000	200	1.8	0.39	33	5.4	7000	0.17	7.5	16.2	8
	MA60-630-AB	0.64	3000	200	1.8	0.39	33	5.4	7000	0.22	7.5	16.2	8
	MA60-1330-A	1.27	3000	400	2.5	0.51	49.89	7.5	5000	0.28	5.6	14.5	8
	MA60-1330-AB	1.27	3000	400	2.5	0.51	49.89	7.5	5000	0.33	5.6	14.5	8
	MA86-2430-A	2.39	3000	750	3.4	0.78	54.3	10.2	5000	2.45	2.18	7.7	8
	MA86-2430-AB	2.39	3000	750	3.4	0.78	54.3	10.2	5000	2.58	2.18	7.7	8
	MA130-5310-A	5.25	1000	550	3.43	1.68	117.3	10.3	2000	6.26	3.58	18.33	8
	MA130-5310-AB	5.25	1000	550	3.43	1.68	117.3	10.3	2000	6.58	3.58	18.33	8
AMD2000 D2009	MA80-2430-A	2.39	3000	750	4.3	0.61	52.09	12.9	5000	0.94	2.1	8.63	8
	MA80-2430-AB	2.39	3000	750	4.3	0.61	52.09	12.9	5000	1.07	2.1	8.63	8
	MA130-4830-A	4.78	3000	1500	7.06	0.74	51.7	21.2	5000	6.26	0.65	3.58	8
	MA130-4830-AB	4.78	3000	1500	7.06	0.74	51.7	21.2	5000	6.58	0.65	3.58	8
	MA130-7220-A	7.16	2000	1500	7.57	1.06	72.5	22.71	4000	8.88	0.79	4.74	8
	MA130-7220-AB	7.16	2000	1500	7.57	1.06	72.5	22.71	4000	9.20	0.79	4.74	8
	MA130-9620-A	9.55	2000	2000	9.18	1.14	79.6	27.5	3500	12.14	0.58	3.78	8
	MA130-9620-AB	9.55	2000	2000	9.18	1.14	79.6	27.5	3500	12.46	0.58	3.78	8

13.2.13 Brake Motor Specific Information

Order Code	Brake Current (A)	Brake Active Time (ms)	Brake Release Time (ms)	Weight (kg)	Rotor Inertia (kg/cm^2)	Static Friction Torque (Nm)	Connector Type
MA60-1330-AB	0.262	17	32	0.4	0.049	2	N
MA86-2430-AB	0.43	35	25	0.65	0.129	3	N
MA130-5310-AB	0.816	27	76	1.1	0.324	20	C
MA80-2430-AB	0.43	35	25	0.65	0.129	3	N
MA130-4830-AB	0.816	27	76	1.1	0.324	20	C
MA130-7220-AB	0.816	27	76	1.1	0.324	20	C
MA130-9620-AB	0.816	27	76	1.1	0.324	20	C

N: Flying Lead (no connector) C: MS Connector

13.2.14 Motor Mechanical Information Summary



	Order code	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	G (mm)	H (mm)	Weight (kg)	IP Rating*[18]	Insulation Grade	Connector Style
AMD2000 D2003	MA60-0630-A	112.8	60	50	14	30	27	70	5.5	1.03	IP67	F (155°C)	AMP
	MA60-0630-AB	147.3	60	50	14	30	27	70	5.5	1.43	IP67	F (155°C)	AMP
	MA60-1330-A	132.8	60	50	14	30	27	70	5.5	1.37	IP67	F (155°C)	AMP
	MA60-1330-AB	167.3	60	50	14	30	27	70	5.5	1.77	IP67	F (155°C)	AMP
	MA86-2430-A	148	86	80	16	35	32	100	6.5	3.41	IP67	F (155°C)	AMP
	MA86-2430-AB	183.2	86	80	16	35	32	100	6.5	4.06	IP67	F (155°C)	AMP
	MA130-5310-A	164.8	130.4	110	22	58	52	145	9	6.47	IP67	B (130°C)	MS
	MA130-5310-AB	219.3	130.4	110	22	58	52	145	9	7.57	IP67	B (130°C)	MS
AMD2000 D2009	MA80-2430-A	139	80	70	19	40	37	90	5.5	2.47	IP67	F (155°C)	AMP
	MA80-2430-AB	174	80	70	19	40	37	90	5.5	3.12	IP67	F (155°C)	AMP
	MA130-4830-A	164.8	130.4	110	22	58	52	145	9	6.47	IP67	B (130°C)	MS
	MA130-4830-AB	219.3	130.4	110	22	58	52	145	9	7.57	IP67	B (130°C)	MS
	MA130-7220-A	183.8	130.4	110	22	58	52	145	9	8.08	IP67	B (130°C)	MS
	MA130-7220-AB	238.3	130.4	110	22	58	52	145	9	9.18	IP67	B (130°C)	MS
	MA130-9620-A	214.8	130.4	110	22	58	52	145	9	10.18	IP67	B (130°C)	MS
	MA130-9620-AB	269.3	130.4	110	22	58	52	145	9	11.28	IP67	B (130°C)	MS

[18] IP rating excludes electrical connector and shaft

13.3 Cables

13.3.11 Cable Catalogue Number Interpretation

K 2 A - F S P D - 0 2 0

Product
K: Cable

Servo Drive Series
2: AMD2000
5: AMD5000

Motor Type
A: Alpha Series
B: Beta Series

Cable Type
F: Feedback
A: Armature
B: Armature with Brake

Shielding
S: Shielded
U: Unshielded

Connector Type
P: Plastic
M: Metal

Specials
D: Default

Length
020: 2 Metre
030: 3 Metre
050: 5 Metre
100: 10 Metre

13.3.12 Encoder Cables

13.3.12.1 Encoder Cables (Plastic/AMP)

Catalogue Number	Length
K2A-FSPD-020	2m
K2A-FSPD-030	3m
K2A-FSPD-050	5m
K2A-FSPD-100	10m

13.3.12.2 Encoder Cables (Metal/MS)

Catalogue Number	Length
K2A-FSMD-020	2m
K2A-FSMD-030	3m
K2A-FSMD-050	5m
K2A-FSMD-100	10m

13.3.13 Armature Cables

13.3.13.1 Shielded Armature Cables (Plastic/AMP)

Catalogue Number	Length
K2A-ASPD-020	2m
K2A-ASPD-030	3m
K2A-ASPD-050	5m
K2A-ASPD-100	10m

13.3.13.2 Shielded Armature Cables (Metal/MS)

Catalogue Number	Length
K2A-ASMD-020	2m
K2A-ASMD-030	3m
K2A-ASMD-050	5m
K2A-ASMD-100	10m

13.3.13.3 Shielded Armature Cables with Brake (Metal/MS)

Catalogue Number	Length
K2A-BSMD-020	2m
K2A-BSMD-030	3m
K2A-BSMD-050	5m
K2A-BSMD-100	10m

13.4 Other Accessories

13.4.11 I/O Interface Accessories

Part Number	Description
619-0-00-0965	***AMD2000 I/O Interface Module Kit***
ICN-3077-1150	1 x AMD2000 I/O Interface Module
ICN-1026-1190	1 x AMD2000 I/O Interface Cable

13.4.12 EtherCAT Cables

Part Number	Description
ICN-1026-1233	Ethernet Cable, Cat 5e, SF/UTP, 200mm
ICN-1026-1097	Ethernet Cable, Cat 5e, SF/UTP, 1m
ICN-1026-1098	Ethernet Cable, Cat 5e, SF/UTP, 3m
ICN-1026-1099	Ethernet Cable, Cat 5e, SF/UTP, 5m

13.4.13 Armature Shield Clamping Brackets

Part Number	Description
619-0-00-0957	AM2000 9A Armature Bracket Kit

13.4.14 AMD2000 3A EMC Kit

Part Number	Description
619-0-00-0966	***AMD2000 3A EMC Kit***
ICN-3096-1665	Schaffner FN 3270H-10-44
ICN-3096-0048	Schaffner FN 343-3-05
ICN-3096-1661	Hammond Manufacturing 159ZJ
ICN-3096-1663	King Core KCF-130-B
ICN-3096-1664	King Core K5B T 29x7.7x19
ICN-3096-0049	JFE R-60/40/25B MA055-C

13.4.15 AMD2000 9A EMC Kit

Part Number	Description
619-0-00-0967	***AMD2000 3A EMC Kit***
ICN-3096-1665	Schaffner FN 3270H-10-44
ICN-3096-0048	Schaffner FN 343-3-05
ICN-3096-1662	Hammond Power Solutions RM0012N13
ICN-3096-1663	King Core KCF-130-B

ICN-3096-1664	King Core K5B T 29x7.7x19
ICN-3096-0049	JFE R-60/40/25B MA055-C

13.4.16 EMI Filters

Part Number	Description
ICN-3096-1665	Schaffner FN 3270H-10-44
ICN-3096-0048	Schaffner FN 343-3-05

13.4.17 Line Reactors

Part Number	Description
ICN-3096-1662	Hammond Power Solutions RM0012N13

13.4.18 DC Chokes

Part Number	Description
ICN-3096-1661	Hammond Manufacturing 159ZJ

13.4.19 Magnetic Cores

Part Number	Description
ICN-3096-1663	King Core KCF-130-B
ICN-3096-1664	King Core K5B T-29x7.7x19
ICN-3096-0049	JFE R-60/40/25B MA055-C

13.5 Starter Kits

13.5.11 AMD2000 3A Starter Kit

Part Number	*Description*
619-0-00-0971	***AMD2000 3A Starter Kit***

D2003-2S1-A	AMD2000 Series Servo Drive
MA60-0630-A	Alpha Series Servo Motor
K2A-FSPD-020	Alpha Motor Cable
K2A-ASPD-020	Alpha Motor Cable
ICN-1026-1097	Ethernet Cable, Cat 5e, SF/UTP, 1m

13.5.12 AMD2000 9A Starter Kit

Part Number	Description
619-0-00-0972	***AMD2000 9A Starter Kit***
D2009-2S1-A	AMD2000 Series Servo Drive
MA80-2430-A	Alpha Series Servo Motor
K2A-FSPD-020	Alpha Motor Cable
K2A-ASPD-020	Alpha Motor Cable
ICN-1026-1097	Ethernet Cable, Cat 5e, SF/UTP, 1m

14. Additional Information

14.1 What this Chapter Contains

This chapter contains information on product support and feedback:

- Contact Information
- Feedback on the manual

14.2 Maintenance and Repairs

DANGER HIGH VOLTAGE - The working DC bus is live at all times when power is on. The Main Isolator feeding the drive must be switched to the **Off** position at least 15 minutes before any work is commenced on the unit. The operator must check the bus voltage with a tested working voltage measuring instrument prior to disconnecting any connectors or opening the DC Bus terminal cover. The red LED indicator on the front of the drive which indicates that there is charge remaining in the drive is only to be used as an aid to visual troubleshooting. **It shall not be relied on as a means of safety.**

There are no user serviceable parts inside the AMD2000 drive; therefore maintenance only involves inspection of the drive its connections and enclosure. Make sure that all connections are fitted correctly and that there are no signs of damage. Check that all wires are tightly fitted to the connectors and that there are no signs of discolouration which may indicate heating. Make sure all drive covers are securely fitted and that they have no signs of damage. Make sure that the drive enclosure is free from dust or anything that may inhibit its operation. Refer to section *Mechanical Installation* for site requirements, tools, and installation and uninstallation information.

There are no internal adjustments inside the AMD2000. For any repairs please contact our nearest office or agent. Refer to section *Product, Sales and Service Enquiries.*

14.3 Product, Sales and Service Enquiries

If you require assistance for installation, training or other customer support issues, please contact the closest ANCA Motion Customer Service Office in your area for details.

ANCA Motion Pty. Ltd.
1 Bessemer Road
Bayswater North
VIC 3153
AUSTRALIA
Telephone: +61 3 9751 7333
Fax: +613 9751 7301
www.ancamotion.com/Contact-Us
Email: sales.au@ancamotion.com

ANCA Motion Taiwan
1F, No.57, 37 Road
Taichung Industrial Park
Taichung 407
TAIWAN
Telephone: +886 4 2359 0082
Fax: +886 4 2359 0067
http://www.ancamotion.com/Contact-Us
Email: sales.tw@ancamotion.com

14.4 Feedback

This Manual is based on information available at the time of publication. Reasonable precautions have been taken in the preparation of this Manual, but the information contained herein does not purport to cover all details or variations in hardware and software configuration. Features may be described herein which are not present in all hardware and software systems. We would like to hear your feedback via our website: www.ancamotion.com/Contact-Us